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# **Global Emissions of Carbon Dioxide from Petroleum Sources**

**HEALTH AND ENVIRONMENTAL AFFAIRS  
DEPARTMENTAL REPORT NUMBER DR 141  
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# **Global Emissions of Carbon Dioxide from Petroleum Sources**

**Health and Environmental Affairs  
Departmental Report No. DR 141**

**PREPARED UNDER CONTRACT BY:**

**RADIAN CORPORATION  
EAST CHAPEL HILL ROAD/NELSON HIGHWAY  
RESEARCH TRIANGLE PARK, NORTH CAROLINA**

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**American  
Petroleum  
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## CONTENTS

<u>Section</u>		<u>Page</u>
1.0	INTRODUCTION .....	1-1
2.0	EXECUTIVE SUMMARY .....	2-1
3.0	PETROLEUM INDUSTRY OVERVIEW .....	3-1
	3.1 Exploration and Extraction .....	3-3
	3.2 Crude Transportation .....	3-6
	3.3 Refining Operations .....	3-6
	3.4 Product Transportation .....	3-9
	3.5 End Uses .....	3-10
4.0	PETROLEUM ACTIVITY DATA DEVELOPMENT .....	4-1
	4.1 Exploration and Extraction .....	4-2
	4.2 Crude Transportation .....	4-3
	4.3 Refining Operations .....	4-4
	4.4 Product Transportation .....	4-4
	4.5 End Uses .....	4-5
5.0	EMISSION FACTOR DEVELOPMENT .....	5-1
	5.1 Exploration and Extraction .....	5-1
	5.2 Crude Transportation .....	5-2
	5.3 Refining Operations .....	5-3
	5.4 Product Transportation .....	5-4
	5.5 End Uses .....	5-4
	5.6 Carbon Dioxide Emissions Scaling Factors .....	5-5
6.0	CARBON DIOXIDE EMISSIONS FROM PETROLEUM SOURCES ..	6-1
	6.1 Exploration and Extraction .....	6-7
	6.2 Crude Transportation .....	6-7
	6.3 Refining Operations .....	6-8

## CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
6.4 Product Transportation .....	6-8
6.5 End Uses .....	6-8
7.0 REFERENCES .....	7-1

### Appendix A – Emissions Estimates by Country, Region, and Emission Sources

## TABLES

<u>Number</u>		<u>Page</u>
3-1	Petroleum Industry Activities and CO <sub>2</sub> Emission Factors . . . . .	3-2
4-1	1987 Global Consumption of Petroleum Products . . . . .	4-6
6-1	CO <sub>2</sub> Emissions Estimates - Regional Summaries . . . . .	6-2
6-2	Summary of Related Studies . . . . .	6-6
A-1	World Petroleum Industry CO <sub>2</sub> Emissions Estimates . . . . .	A-1
A-2	World Petroleum Industry Drilling/Extraction CO <sub>2</sub> Emissions Estimates . . . . .	A-9
A-3	World Petroleum Industry Crude Transportation CO <sub>2</sub> Emissions Estimate . . . . .	A-14
A-4a	World Petroleum Industry Refinery CO <sub>2</sub> Emissions Estimates . . . . .	A-19
A-4b	World Petroleum Industry Refinery CO <sub>2</sub> Emissions Estimates . . . . .	A-27
A-5	World Petroleum Industry Product Transportation CO <sub>2</sub> Emissions Estimate . . . . .	A-35
A-6	World Petroleum Industry End Use CO <sub>2</sub> Emissions Estimates . . . . .	A-40

## FIGURES

<u>Number</u>		<u>Page</u>
2-1	Petroleum industry segments contributing to global carbon dioxide emissions .....	2-3
2-2	Geographic regions used in the CO <sub>2</sub> emissions inventory .....	2-4
6-1	Annual global CO <sub>2</sub> emissions from petroleum by activity .....	6-3
6-2	Breakdown of regional CO <sub>2</sub> emissions by industry segment. Global CO <sub>2</sub> emissions estimated at 9,246,131,416 tons per year .....	6-4
6-3	Annual U.S. CO <sub>2</sub> emissions from petroleum by activity .....	6-5



## 1.0 INTRODUCTION

The analysis and interpretation of recent atmospheric, oceanographic, and earth sciences data suggests that significant changes in current global climate patterns may occur as a result of the accumulation of carbon dioxide (CO<sub>2</sub>) and other greenhouse gases in the Earth's atmosphere. The nature of area- or region-specific climate shifts are still uncertain with regard to type (i.e., temperature change, precipitation modification, change in frequency of severe storms, sea level fluctuations, etc.), magnitude, and timing. Given the possible severe and irreversible consequences of climate change to global socio-economic parameters, further study of greenhouse gas emission rates and emission reduction techniques is warranted.

Carbon dioxide is hypothesized to contribute approximately half of the increasing concentrations of greenhouse gases that are potentially creating shifts in global climate patterns. The atmospheric concentration of CO<sub>2</sub> has increased from about 280 ppm in 1800 to 353 ppm in 1990 (Houghton et al., 1990). The current rate of increase in atmospheric CO<sub>2</sub> concentration is 0.5 percent per year (Houghton et al., 1990). Although natural exchanges of CO<sub>2</sub> between the atmosphere and the biosphere (oceans, biomass, soils) are estimated in excess of 200 billion tons per year of carbon, the current 5.5 billion tons of carbon emissions (equivalent to 20.2 billion tons of CO<sub>2</sub>) resulting from fossil fuel combustion is thought to be a primary factor in the rise in atmospheric CO<sub>2</sub> concentrations in the past 180 years (Lashof and Tirpak, 1989). Between 0.4 and 2.6 billion tons of carbon emissions (1.5 to 9.5 billion tons of CO<sub>2</sub>) are attributed to deforestation.

The largest sources of anthropogenic CO<sub>2</sub> are from fossil fuel combustion, including coal, oil, and natural gas. Coal and oil each contribute about 40 percent with natural gas

contributing about 20 percent to the total fossil fuel emissions of CO<sub>2</sub>. Because of the large part CO<sub>2</sub> plays in estimates of total climate change potential, coal and oil can each be expected to contribute about 20 percent of the total change. Consequently, the examination of the energy industries is important in understanding the emissions from such sources in terms of potential impacts to global climate change.

The International Panel on Climate Change (IPCC) has concluded that increases in CO<sub>2</sub>, methane, and other greenhouse gases will promote climate change (Houghton et al., 1990). The objective of this report is to present estimates of CO<sub>2</sub> emissions from all segments of the global petroleum industry. These estimates are based on available data associated with individual petroleum industry segments. CO<sub>2</sub> emission estimates for certain regions and/or industry segments that were calculated from incomplete or otherwise inadequate data are identified. Emissions associated with the coal and natural gas industries are not presented.

## **2.0 EXECUTIVE SUMMARY**

In this study, CO<sub>2</sub> emission estimates have been developed for a broadly defined petroleum industry that encompasses everything from locating oil reserves through end uses of the oil products. The industry has been divided into five major segments: (1) exploration and extraction, (2) crude petroleum transportation to refineries, (3) refining operations, (4) refinery products transportation, and (5) end uses. Carbon dioxide emission estimates have been developed for each industry segment for each country by multiplying an activity factor by an emission factor. Activity factors describe the activity level for a particular industrial activity such as crude transportation. The units of measure selected for activity factors were those for which country-specific data were available or could be calculated. For example, barrel-miles were used for crude transportation and barrels of throughput were used for refinery operations. Corresponding emission factors for each activity factor were developed from EPA and industry documents.

The results of this report are global estimates of CO<sub>2</sub> emissions by industry segment and by country and region. The global petroleum industry segment with the largest estimated total emissions is end uses with 8.4 billion tons per year of CO<sub>2</sub> emissions or almost 91 percent of the total. Refinery operations had the second highest emissions with 0.5 billion tons per year of CO<sub>2</sub> emissions or 6 percent of the total. North America was clearly the largest CO<sub>2</sub> emitting region with nearly 30 percent (2.83 billion tons per year) of the total global CO<sub>2</sub> emissions generated by the petroleum industry.

These results generally agree with other estimates for global petroleum industry CO<sub>2</sub> emissions. The draft EPA report to Congress entitled "Policy Options for Stabilizing Global Climate" (Lashof and Tirpak, 1989) gave an estimate of 8.1 billion tons of CO<sub>2</sub> emissions per year from oil consumption. This estimate includes the end use segments reported

here and portions of the remaining industry segments. When considered on an equivalent basis, the estimate from this report is approximately 12 percent higher than the EPA estimate. The results of this report have also been compared to results from the Edmonds-Reilly global CO<sub>2</sub> emissions model (Edmonds and Reilly, 1983). Their model predicted 1987 global CO<sub>2</sub> emissions from oil to be 8.9 billion tons per year. When considered on an equivalent basis, the CO<sub>2</sub> total emissions estimate reported here is within 3 percent of the Edmonds-Reilly model prediction. Data were not available for all countries. The fractional contributions of CO<sub>2</sub> emissions from reported countries would slightly decrease given the small increase in total global emissions if data were available for every country.

The technical overview of the petroleum industry is limited to basic descriptions and definitions of the identified industry segments and associated processes for which emission factors were derived (Figure 2-1). The geographic regions considered are also presented (Figure 2-2).

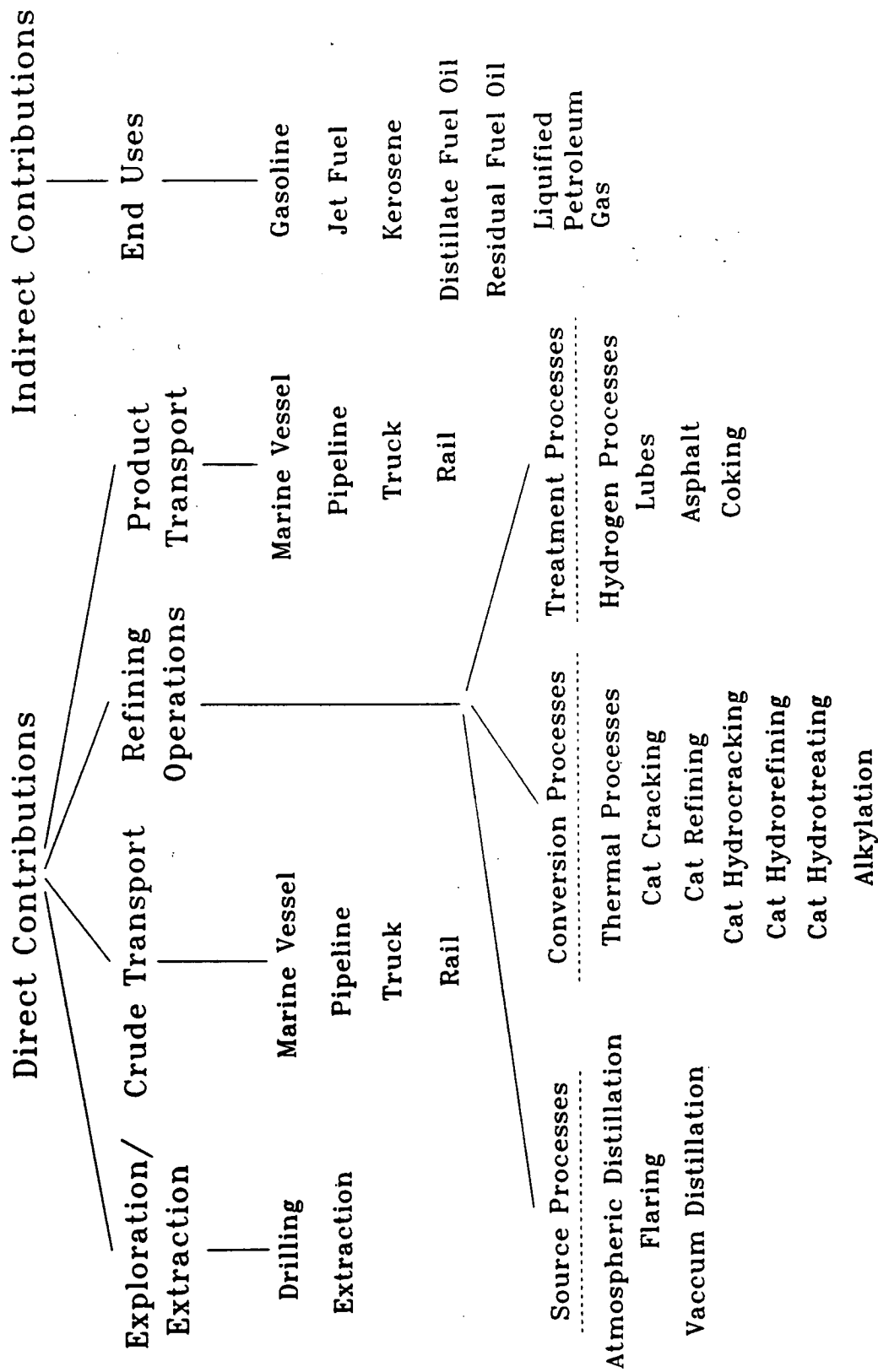


Figure 2-1. Petroleum industry segments contributing to global carbon dioxide emissions.

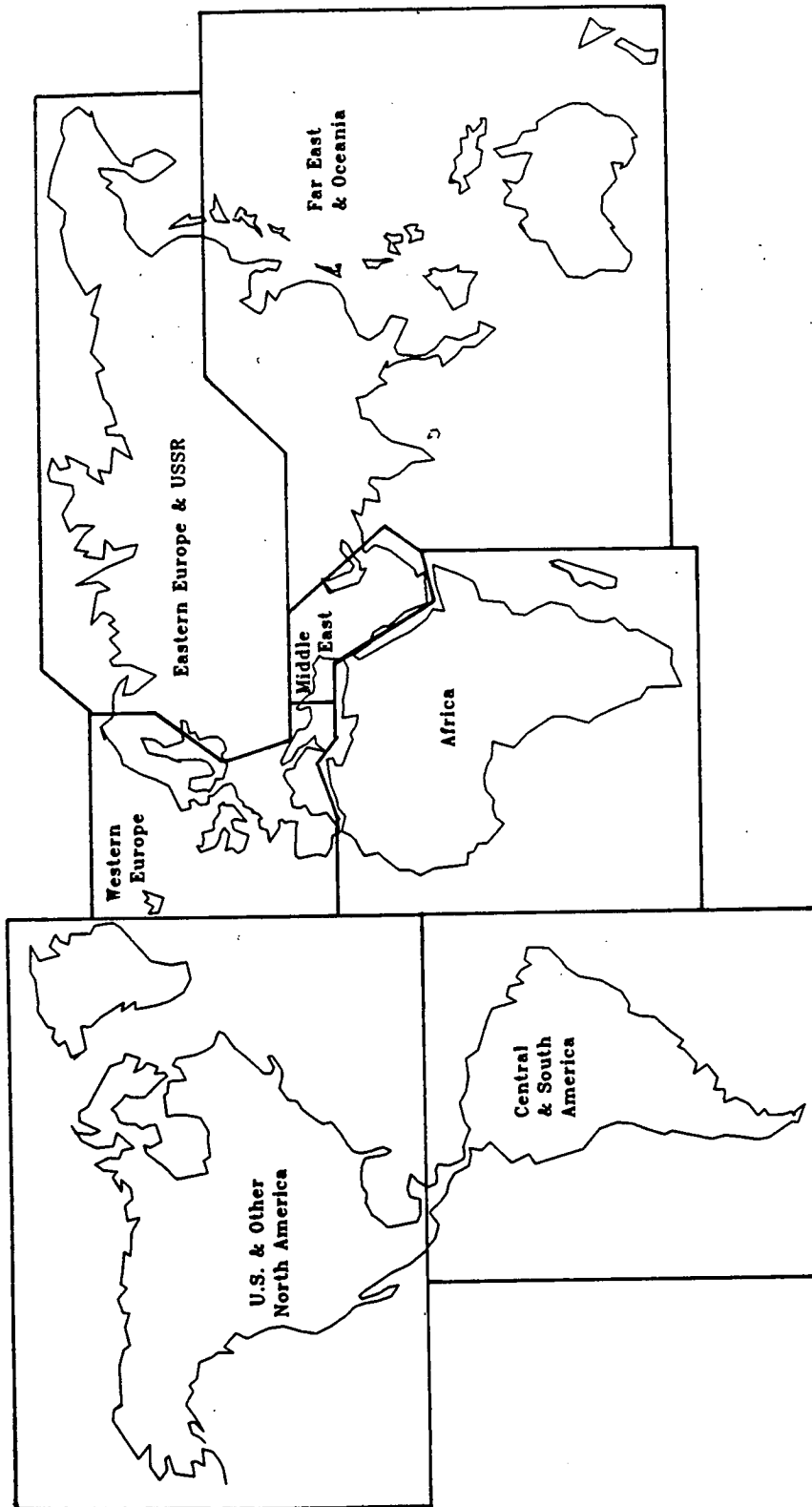


Figure 2-2. Geographic regions used in the CO<sub>2</sub> emissions inventory.

### **3.0 PETROLEUM INDUSTRY OVERVIEW**

The definition of the petroleum industry used in this report encompasses all activities beginning with location of oil reservoirs through consumer use of petroleum products. The CO<sub>2</sub> emission estimates for this broadly defined industry have been divided into five major segments:

1. Exploration and Extraction,
2. Crude Petroleum Transportation to Refineries,
3. Refining Operations,
4. Refinery Products Transportation, and
5. End Uses.

Sources of CO<sub>2</sub> emissions were identified within each industry segment. In order to quantify emissions from each source, emissions were evaluated as a function of industry activity and rate at which the activity causes emissions. This rate is represented as an emission factor. For example, CO<sub>2</sub> emissions from well drilling are a function of the number of wells drilled and the amount of CO<sub>2</sub> emitted from a typical drilled well. In this case, the source of CO<sub>2</sub> emissions is well drilling, the activity level is the number of wells drilled, and the emission factor is the amount of CO<sub>2</sub> emissions per well site. Sources of emissions, activities, and emission factors for all industry segments are illustrated in Table 3-1.

TABLE 3-1. PETROLEUM INDUSTRY ACTIVITIES AND CO<sub>2</sub> EMISSION FACTORS

Major Category	Emission Source	Petroleum Activity	Emission Factor	Units of Emission Factor
Exploration/Extraction	Well prep. and drilling -prep. equipment -gas fired	Number of wells drilled Number of wells drilled	2887.4 0.03	tons CO <sub>2</sub> /well drilled tons CO <sub>2</sub> /well drilled
	Field prod. and proc. -processing equipment -gas flaring	Number of active wells Number of active wells	1.2 2.3	tons CO <sub>2</sub> /active well/yr tons CO <sub>2</sub> /active well/yr
Crude Transportation	Tank trucks	bbl mile	0.00001	tons CO <sub>2</sub> /bbl mile
	Marine vessels	bbl mile	0.000001	tons CO <sub>2</sub> /bbl mile
	Railcar	bbl mile	0.000006	tons CO <sub>2</sub> /bbl mile
	Pipeline	bbl mile	0.000003	tons CO <sub>2</sub> /bbl mile
Refinery Operations (heaters and boilers)	Atmospheric separation	bbl thruput	0.008	tons CO <sub>2</sub> /bbl thruput
	Thermal processes	bbl thruput	0.08	tons CO <sub>2</sub> /bbl thruput
	Catalytic reformation	bbl thruput	0.002	tons CO <sub>2</sub> /bbl thruput
	Catalytic hydrotreating	bbl thruput	0.025	tons CO <sub>2</sub> /bbl thruput
	Alkylation reactions	bbl thruput	0.03	tons CO <sub>2</sub> /bbl thruput
	Hydrogen processes	bbl thruput	0.02	tons CO <sub>2</sub> /bbl thruput
	Vacuum separation	bbl thruput	0.008	tons CO <sub>2</sub> /bbl thruput
	Catalytic cracking	bbl thruput	0.008	tons CO <sub>2</sub> /bbl thruput
	Catalytic hydrocracking	bbl thruput	0.02	tons CO <sub>2</sub> /bbl thruput
	Catalytic hydrotreating	bbl thruput	0.006	tons CO <sub>2</sub> /bbl thruput
	Aromatic/isomerization	bbl thruput	0.03	tons CO <sub>2</sub> /bbl thruput
	Lubes	bbl thruput	0.01	tons CO <sub>2</sub> /bbl thruput
	Asphalts	bbl thruput	0.006	tons CO <sub>2</sub> /bbl thruput
	Cokes	bbl thruput	0.007	tons CO <sub>2</sub> /bbl thruput
	Refinery flaring	bbl capacity	0.00004	tons CO <sub>2</sub> /bbl capacity
Product Transportation	Tank trucks	bbl mile	0.00001	tons CO <sub>2</sub> /bbl mile
	Marine vessels	bbl mile	0.000001	tons CO <sub>2</sub> /bbl mile
	Railcar	bbl mile	0.000005	tons CO <sub>2</sub> /bbl mile
	Pipeline	bbl mile	0.000003	tons CO <sub>2</sub> /bbl mile
End Uses	Gasoline	bbl	0.4	tons CO <sub>2</sub> /bbl
	Diesel (fuel oil No. 2)	bbl	0.5	tons CO <sub>2</sub> /bbl
	Kerosene	bbl	0.5	tons CO <sub>2</sub> /bbl
	Jet fuel	bbl	0.5	tons CO <sub>2</sub> /bbl
	Residual fuel oil	bbl	0.5	tons CO <sub>2</sub> /bbl
	Liquidified petroleum gas	bbl	0.3	tons CO <sub>2</sub> /bbl



### **3.1 EXPLORATION AND EXTRACTION**

Exploration and extraction activities include geological surveying and testing, exploratory and delineation drilling, and field drilling and production. Geological test methods are required to establish the presence of an oil reservoir. Typical survey and test methods for onshore and offshore wells include remote sensing (digital imagery and aerial photography), acoustic sounding (used for offshore wells), and seismic testing. Once the potential for oil development has been established in an area, exploratory drilling is employed to determine if sufficient resources exist to merit development. If the results of the exploratory drilling are satisfactory, delineation wells are drilled to determine the optimum locations for production wells. Delineation drilling starts shortly after exploratory drilling is completed.

The number of exploratory and delineation wells drilled in a reservoir is a function of the quantity of resources expected to be found in the area and the areal extent of the find. A larger find results in a greater number of wells; a smaller find warrants less exploratory activity. When exploration confirms the presence of sufficient quantities of oil to justify production, the field production and processing phase begins. Activities include the drilling of production wells and the installation of hardware (valve trees, pumps, etc.) necessary to bring the oil to the surface. For offshore production, platform construction and pipeline installation are also required.

Onshore and offshore field production requires drilling, which in its simplest terms involves cutting a hole in the earth's crust. Drilling is accomplished by using a rotary rig to turn a drill string and drill bit to break, dislodge, and fragment formation material. A drilling fluid (also known as a mud) is circulated down the string to the drill bit to cool and

lubricate the drill bits and to transport cuttings to the surface for disposal. Power for drilling is provided by diesel engines.

For offshore platform installation, the jacket and deck modules are fabricated onshore and towed to the offshore site. Once offshore, the jacket is sunk by one or more derrick barges and secured to the sea floor by pinnings. The deck section and components are then attached. The major emissions associated with platform installation are from the equipment on the derrick barges used to lift and secure the components and the tug boats used to tow the jacket modules to the platform.

The extraction stage of the production process involves the recovery of crude oil from the reservoir and the processing of the well stream for shipment to refiners. The two primary steps in this process are extraction and field processing.

Extraction is usually accomplished using one of four methods: natural flow, steam-flooding, natural gas injection, or thermal and chemical treatment. In natural flow extraction, natural reservoir pressure is sufficient to cause oil flow through the subsurface formation to the oil recovery well. However, natural flow wells often do not convey oil to the gathering system on the surface without some energy input from subsurface pumps or gas lifting systems. Gas lifting is accomplished by injecting natural gas into the downhole production tubing at various depths to assist oil flow to the surface. Natural flow recovery is also referred to as primary oil recovery.

Steam flooding and natural gas injection are used after natural flow recovery methods have failed. The use of these techniques is often referred to as secondary recovery. In secondary recovery, natural gas or steam is injected into the geological formation to induce the flow of crude oil to the collection system.

Thermal and chemical treatment methods are used after secondary recovery and are referred to as tertiary recovery or enhanced recovery techniques. Tertiary methods include in situ combustion, which heats the oil and reduces its viscosity, and surfactant injection, which reduces the ability of the formation to retain crude.

After the crude is extracted by one of these recovery methods, it is processed to remove water, solids, and gas that may be produced along with the oil. Water and solids removal is accomplished by allowing sufficient time for free water and solids to settle out and/or by chemically or electrically breaking oil-water emulsions. During this process, gas is also separated from the oil using a variety of processing units. The oil is then ready for shipment to refiners.

Carbon dioxide emissions associated with exploration and extraction can be divided into two categories: power generation and flaring. The primary source of CO<sub>2</sub> emissions during the exploratory phase are the large internal combustion engines that supply power for the drilling rigs. In addition, significant emissions can come from support vessels for offshore wells and earth moving and other heavy equipment in onshore operations. In most cases, the rig engines are diesel-powered. The heavy equipment used in both onshore and offshore operations normally burn diesel fuel. The support vessels for offshore exploration may also use diesel or fuel oil. Carbon dioxide emissions also occur as a result of flaring collected gases that are generated during exploration and extraction activities.

## **3.2 CRUDE TRANSPORTATION**

The transportation of crude oil from field to refinery is, for the most part, accomplished by pipeline and marine tanker. A smaller portion of the crude is also transported by tank truck and railcar.

During transportation, CO<sub>2</sub> emissions result from the exhaust emissions of the vehicle engines. Carbon dioxide emissions from transportation vehicle engines is discussed in greater detail under the End Uses section. The generation of electric power necessary to operate the pipeline pumps creates the CO<sub>2</sub> emissions associated with pipeline transportation.

## **3.3 REFINING OPERATIONS**

Refinery operations convert crude oil into multiple products with a variety of end uses. The scope of petroleum refining includes receiving the crude into storage and the refining operations. The petroleum refining industry employs a variety of processes for generating the desired products. The refining processes can be divided into three distinct categories: separation, conversion, and treatment. This section of the report presents an overview of these three categories.

### **3.3.1 Separation Processes**

The first step in petroleum refining is separating crude oil into its common boiling point components. Crude oil consists of various hydrocarbon compounds including naphthenic, paraffinic, and aromatic hydrocarbons as well as such impurities as oxygen,

nitrogen, sulfur, and various metals. The separation process employs atmospheric and vacuum distillation techniques to separate common boiling point hydrocarbons.

Crude oil is heated in a process heater and then introduced to an atmospheric distillation column for separation of the lighter components. The topped crude drawn from the bottom of the atmospheric distillation column is reheated in the process heater and directed to a vacuum distillation column. Vacuum distillation occurs at a sub-atmospheric pressure allowing lower-temperature separation of the high boiling-point distillates associated with the petroleum crude. Further separations can occur to produce single-component products. The light ends of the atmospheric distillation (and conversion processes) are often further separated to recover  $C_2/C_3/C_4$  compounds. These materials are sold as products or petro-chemical feedstocks. The aromatic fractions of the crude can be separated in a BTX process where benzene, toluene, and o-, m-, and p-xylene are recovered. Steam is often introduced to the distillation columns to enhance the recovery process.

The primary sources of  $CO_2$  emissions from separation processes are associated with process heater and boiler exhausts, and from refinery flaring practices.

### **3.3.2      Conversion Processes**

Once crude oil has been separated into common boiling point fractions, hydrocarbon molecules are converted into either larger- or smaller-size molecules. Large petroleum molecules are reduced to smaller molecules during thermal and catalytic cracking.

Cracking involves the decomposition and recombination of petroleum molecules primarily into motor fuels. Molecular structure is changed by a series of condensation reactions that result in the transfer of hydrogen atoms between molecules. The thermal cracking process exposes the hydrocarbon distillate to high temperatures for varying time periods to physically reorganize the distillate molecule. Thermal cracking has been largely displaced by catalytic cracking.

Catalytic cracking employs a metal catalyst to form high-octane gasoline. When distillate gas oil feedstock is passed through the catalyst, molecular recombination occurs rapidly, forming the smaller hydrocarbon molecules. Catalytic cracking is the most commonly used cracking process.

In other processing steps, small petroleum molecules are combined into larger molecules by polymerization and alkylation processes. Polymerization involves a reaction, generally carried out in the presence of a catalyst, where relatively simple molecules (monomers) are combined to form a molecule with a chain-like structure. The new chain-like molecules are referred to as polymers. Alkylation involves the introduction of an alkyl radical with a simple organic molecule. This reaction occurs in the presence of a catalyst to form a high-octane blending component for gasoline.

Molecular structure can be rearranged by isomerization and reformation processes to produce molecules with higher-value and greater utilization. Isomerization is a method of altering the arrangement of the atoms of a hydrocarbon molecule without changing the total number of atoms. Isomerization is generally used to convert straight-chain to branched-chain hydrocarbons or to convert aliphatic to aromatic hydrocarbons.

Most of the conversion processes require steam and/or heat to drive the chemical reactions. The primary sources of CO<sub>2</sub> emissions from these conversion processes include process heater and boiler exhausts and safety flare emissions.

### **3.3.3      Treatment Processes**

The final step in the manufacture of petroleum products is process treatment. In this step, the petroleum products are stabilized and, in some cases, the product is separated from less desirable products to remove any contaminants. Typical treatment processes include hydrosulfurization, hydrotreating, chemical sweetening, deasphalting, and acid gas removal. The overall purpose of treatment includes the improvement of color and odor; removal of sulfur compounds; removal of gums, resins, and asphaltic materials; improvement of stability in the presence of sunlight and air; and improvement of susceptibility to additives.

The CO<sub>2</sub> emission sources associated with treatment processes include process heater and boiler exhausts, and flaring losses.

## **3.4    PRODUCT TRANSPORTATION**

Upon completion of the refining of petroleum products, the products are transported to various consumers and to petrochemical production facilities. The product transportation modes include pipeline, marine vessel, railcar, and tank truck. Carbon dioxide emissions occur from the combustion of distillate, diesel, and gasoline fuels required to operate the product carrier vehicles. Carbon dioxide is also emitted from the fuel combustion necessary to operate the pumps for pipeline transportation. This fuel

combustion can occur either on-site in engines used to operate the pipeline pumps or off-site in the generation of electric power to operate pipeline pumps.

### **3.5 END USES**

There are three major categories of end uses for petroleum products that cause emissions of CO<sub>2</sub>: transportation fuels, heating fuels, and fuels for electric power generation. A fourth end use category, chemical feedstocks, does not result in CO<sub>2</sub> emissions that can be attributed to the petroleum industry. The largest consumer of petroleum products is the transportation fuels segment, particularly motor vehicle gasoline. This section focuses on CO<sub>2</sub> emissions from the combustion of transportation fuel.

The quantity of CO<sub>2</sub> emitted is a function of the chemical characteristics of the fuel. Transportation fuels are used by various vehicles including automobiles, aircraft (both commercial and private), trucks, buses, trains, ships, and boats, with automobiles constituting the largest demand for motor gasoline. Gasoline-powered vehicle engines are internal combustion spark-ignition engines. These engines emit numerous combustion products including CO<sub>2</sub> as a result of the fuel combustion process.

Aircraft fuels include both naphtha-type and kerosene-type jet fuel and aviation gasoline. Aircraft engines include jet engines (turbofan, turbojet, and turboprop) and reciprocating piston engines. Diesel trucks, buses, and railroad locomotives are also major users of transportation fuels derived from petroleum. Nearly all of these vehicles are diesel fueled (some commercial trucks are gasoline powered, and a small percentage of trucks and buses are fueled with liquid propane gas).



**Ships, barges, and other watercraft are powered by petroleum-derived fuels. The largest vessels such as tankers and freighters are fired with residual fuel oil. Steamships, the largest marine vessels, are powered by steam turbines, with steam generated by a coal- or oil-fired boilers. Other large marine vessels such as automobile or passenger ferries may be powered by large internal combustion (diesel) engines, and are called motor vessels. Smaller pleasure boats generally use motor gasoline or diesel fuel for their engines. Carbon dioxide is emitted from the fuel combustion in all the marine vessels identified above.**

**All petroleum fuel uses, including transportation, heating, and electric power generation, release their energy through the combustion process in either internal or external combustion devices or engines. The major product from petroleum combustion is CO<sub>2</sub>, which is exhausted to the atmosphere.**



#### **4.0 PETROLEUM ACTIVITY DATA DEVELOPMENT**

The five major segments of the petroleum industry discussed in Section 3.0, exploration/extraction, crude transport, refining, product transport, and end uses, were evaluated to estimate emissions of CO<sub>2</sub>. Carbon dioxide emissions were calculated as a function of the level of activity within the respective petroleum industry segments. Examples include the number of wells drilled, the amount of oil transported by marine vessels, catalytic cracking throughput, and gasoline consumption.

The literature on the petroleum industry was thoroughly reviewed and petroleum industry statistics were gathered from several sources. All efforts were made to use the most recent available data. Data from 1989 were used to represent oil exploration/extraction and refining; data from 1987 through 1988 were used to represent crude and product transport and end use. Emissions estimates were calculated by developing a series of equations with the following form:

$$\text{CO}_2 \text{ Emissions} = \text{Activity Level} * \text{Emission Factor}$$

Emission sources, activity levels, and emission factors were presented in Table 3-1.

The databases used to develop global CO<sub>2</sub> emissions estimates from petroleum sources for this report vary in their level of accuracy and completeness. Every effort was made to obtain activity data for all major oil-producing and consuming countries. However, in some instances data for communist bloc countries were unavailable. The sources, development, and limitations of the activity data used to calculate global CO<sub>2</sub> emissions from petroleum industry sources are discussed in the following sections.

## **4.1 EXPLORATION AND EXTRACTION**

To determine CO<sub>2</sub> emissions from exploration and extraction, two types of data were examined. First, the number of wells drilled each year was used to estimate CO<sub>2</sub> emissions from exploration. Second, the number of producing wells was used in determining emissions from extraction.

Carbon dioxide emissions from oil production and use include natural gas production in oil fields and all active oil and gas rigs associated with the exploration and extraction industry segment. Similar techniques are used to extract both crude oil and natural gas. Often natural gas and crude oil are produced from the same well. U.S. state and federal agencies in charge of counting oil and natural gas wells use different criteria for defining a co-producing well as oil producing or natural gas producing. For these reasons, it was not possible to separate data for oil wells from natural gas wells. However, it was possible to separate oil field data from gas field data. Therefore, data for total oil and gas well activity at oil fields were used to estimate production activities.

The Oil and Gas Journal International Rig Count [Oil and Gas Journal (OGJ), 1990a] was used as the source of the total number of wells drilled in 1989 on a country-by-country basis. The average rig operating in the United States in 1988 drilled 36.9 wells (Pennwell, 1990a).

$$34,579 \text{ wells drilled} / 936 \text{ active rotary rigs} = 36.9 \text{ wells per rig}$$

The U.S. average was applied to the international rig count to estimate the number of wells drilled in 1989 for each country throughout the world. Data describing the number of active rigs and exploration activities were not available for communist countries. This

approach overestimates the number of wells drilled in oil formations since the total number of wells drilled includes wells drilled in gas formations.

The number of currently producing wells that tap oil formations for each country was obtained from the OGJ Worldwide Field Production Survey (OGJ, 1989). The most recent available data from this survey were for 1988. Data for the United States, the Soviet Union, and China were not available from the survey. Data for these countries were obtained from the 1990 International Petroleum Encyclopedia (Pennwell, 1990b). Data for the remaining communist countries were not available. However, oil production from these countries is roughly one-half of 1 percent of global oil production (EIA, 1989).

## **4.2 CRUDE TRANSPORTATION**

Activity data for the transportation of crude oil are reported in billions of barrel-miles. A barrel-mile is a unit representing the movement of one barrel the distance of 1 mile. Transport data were difficult to obtain, and assumptions about crude movements based on U.S. data were necessary. Four major modes of crude transport were examined: pipelines, marine vessels, trucks, and rail.

Barrel-miles of transport for each major mode of crude transport were available for the United States for 1987 (Sceath, 1989). The amount of crude oil used in the United States (barrels/day) in 1988 was also obtained (EIA, 1989). U.S. crude oil use was then applied to U.S. transport values to determine the amount of oil moved by each mode of transportation for each barrel of crude oil consumed per day. The U.S. ratio was applied to crude use in all other countries (EIA, 1989) to estimate crude movements by mode of transport.

This method was used to obtain the following global estimate for 1988: 8819.4 billion barrel-miles of crude were transported by pipeline, 9904.5 billion barrel-miles by marine vessel, 41.4 billion barrel-miles by truck, and 19.4 billion barrel-miles by rail.

#### **4.3 REFINING OPERATIONS**

Data for refining operations were summarized from the OGJ U.S. and Worldwide Refinery Surveys (OGJ, 1990b and 1990c, respectively). Activity data were aggregated by major production process group for each country. Production processes include atmospheric distillation, vacuum distillation, thermal processes, catalytic cracking, catalytic reforming, catalytic hydrocracking, catalytic hydrotreating, catalytic hydrorefining, catalytic hydrotreating, alkylation, aromatics/isomerization, hydrogen processes, lube production, asphalt production, and coke production.

These data were initially reported in terms of refinery unit capacity. An 87.9 percent capacity factor was applied to convert data from units of capacity to units of production. The capacity factor was calculated from U.S. refinery data (Pennwell, 1990a). Monthly capacity utilization rates were averaged for 1989 to determine the U.S. annual capacity utilization for 1989.

#### **4.4 PRODUCT TRANSPORTATION**

Data for the transportation of petroleum products are reported in billions of barrel-miles. The approach used to calculate product transport was similar to that used to calculate crude transport. Transport data were difficult to obtain, and assumptions were made about product movements based on U.S. data. The same four major modes of product transport were examined: pipelines, marine vessels, trucks, and rail.

Barrel-miles of transport for each of these modes were available for the United States for 1987 (Sceath, 1989). The amount of petroleum products used in the United States (barrels per day) in 1988 was obtained (EIA, 1989). U.S. petroleum product use was applied to the transport values to determine the amount of products moved by each transport mode for each barrel of product consumed per day in the United States. This ratio was applied to petroleum product use in all other countries to determine the product movement by transport mode (EIA, 1989).

These methods provided the following global estimates for 1988: 6957 billion barrel-miles of product were transported by pipeline, 4181 billion barrel-miles by marine vessel, 899 billion barrel-miles by truck, and 343.9 billion barrel-miles by rail.

#### **4.5 END USES**

The consumption of refined petroleum products for heat, power, transportation, and other fuel uses results in large emissions of CO<sub>2</sub>. End use activity data for each country in the world for 1987 was obtained (EIA, 1989). Six major petroleum fuel products were examined: gasoline, kerosene, diesel fuel, jet fuel, residual oil, and liquified petroleum gas (LPG). Global consumption of these products is reported in Table 4-1.

**TABLE 4-1. 1987 GLOBAL CONSUMPTION OF PETROLEUM PRODUCTS**

<b>(Thousands of Barrels per Day)</b>	
<b>Product</b>	<b>Use</b>
<b>Gasoline</b>	<b>16,422</b>
<b>Jet Fuel</b>	<b>3,193</b>
<b>Kerosene</b>	<b>1,793</b>
<b>Diesel Fuel</b>	<b>15,209</b>
<b>Residual Fuel</b>	<b>12,516</b>
<b>LPG</b>	<b>983</b>
<b>TOTAL</b>	<b>50,116</b>

**SOURCE:** International Energy Annual, 1988.



## **5.0 EMISSION FACTOR DEVELOPMENT**

This section presents the CO<sub>2</sub> emission factors developed for the petroleum industry activities described in Section 4.0. For each activity reported in Section 4.0, the description of the source of CO<sub>2</sub> emissions, the limitations on the emission factors based on availability of data, the origin of the emission factor, and the units of each emission factor are documented. This section also discusses the applicability of the CO<sub>2</sub> emission factors calculated for industrial countries to less developed nations.

### **5.1 EXPLORATION AND EXTRACTION**

Emissions of CO<sub>2</sub> can occur from two specific steps used in exploration and extraction: well preparation and drilling, and oil field production and processing. Development of the emission factors for each of these two specific areas of exploration and extraction is addressed below.

#### **5.1.1 Well Preparation and Drilling**

Two CO<sub>2</sub> emission factors were developed for oil well preparation and drilling; the first was for CO<sub>2</sub> emitted during site preparation and drilling operations, and the second was for CO<sub>2</sub> produced from flaring operations. Well preparation and drilling practices for onshore and offshore locations differ and will be dictated somewhat by local conditions.

For onshore locations, CO<sub>2</sub> is emitted from the combustion of fuel used to operate the drill, earth-moving equipment, and construction equipment. Fuel is also required for support transportation. This study utilizes CO<sub>2</sub> emission factors based upon the fuel

requirement for a single well (Radian, 1989). The preparation equipment emission factor is 2887.4 tons of CO<sub>2</sub> per well (see Table 3-1).

Hydrocarbon gas brought to the surface with drilling fluid is separated from the "mud" and may be vented or flared. Carbon dioxide is emitted from hydrocarbon gas flaring. As reported by Radian (1989), the amount of CO<sub>2</sub> flared is 0.03 tons per well (see Table 3-1).

### **5.1.2     Field Production and Processing**

Oil field production and processing follow the exploration phase. The primary source of CO<sub>2</sub> emissions from field production and processing is from power generation for the required processing equipment and from gas flaring. Power is supplied for production operations by diesel-fired and natural gas-fired turbines and internal combustion engines. Fuel is also required to operate oil lift pumps, gas compressors, water injection equipment and for other activities. Radian (1989) developed a field production CO<sub>2</sub> emission factor by combining the power generation requirements for all operational equipment from a single operating well. The field production and processing equipment emission factor, associated with the operation of processing equipment is 1.2 tons of CO<sub>2</sub> per active well per calendar year. Gas flaring during field production and processing operations contribute 2.3 tons of CO<sub>2</sub> per active well per calendar year.

## **5.2   CRUDE TRANSPORTATION**

During the process of transporting crude oil to refineries, CO<sub>2</sub> is generated from transfer vehicle engines. The four modes used to transport crude to refineries include

marine vessels, tank trucks, railcars, and pipeline transportation (Moretti, 1989; Pelt, 1990b).

Using data collected from transportation associations, transfer vehicle emission factors for marine vessels, tank trucks, and railcars were estimated as a function of the type of fuel and combustion efficiency (Pelt, 1990a). The quantity of CO<sub>2</sub> emitted as engine exhaust was calculated by estimating emissions from the fuel burned over a 1-mile distance with a full load. The estimate was then apportioned over the number of barrels in a full load to determine emissions per barrel-mile. These factors are shown in Table 3-1.

Carbon dioxide emissions result from diesel fuel combustion from pump stations for pipeline transportation. Using pump efficiency and utility data and crude throughput data, a CO<sub>2</sub> emission factor was estimated (Radian, 1976). As presented in Table 3-1, the CO<sub>2</sub> emission factor for pipeline transportation is 0.000003 tons per barrel-mile.

### **5.3 REFINING OPERATIONS**

Crude oil is refined into multiple products with various end uses. Petroleum refining activities that result in CO<sub>2</sub> emissions include the power generation requirements necessary to operate the separation, conversion, and treatment equipment, as well as refinery flaring.

The primary sources of CO<sub>2</sub> emissions from refinery processes are the exhausts from process heaters and boilers. The heating requirement per unit throughput and a breakdown of fuels used were needed to calculate the CO<sub>2</sub> emissions per unit of process throughput. Heaters and boilers typically can combust a variety of fuels and waste gases.

A distribution of the types and proportion of various fuels used in U.S. refineries was obtained (EEA, 1980) as well as the heating requirement per unit of process throughput (Radian, 1980). Carbon dioxide emissions per unit of process throughput were then calculated by combining the amount of heat required with the proportion of various fuels to supply the heat. Using these data, the CO<sub>2</sub> emissions factors for specific petroleum refinery processes were calculated (see Table 3-1).

The typical fuel profile used to calculate the CO<sub>2</sub> emissions from process heaters was also used to calculate emissions from refinery flaring. Flares are used as air pollution control devices for process vents and for controlling releases from pressure relief valves. The typical fuel profile was assumed to be representative of the composition of the waste gas streams controlled by the plant flare. Using these data and a destruction efficiency of 98 percent, the refinery flaring emission factor was calculated to be 0.00004 tons of CO<sub>2</sub> per barrel of capacity (Radian, 1980).

#### **5.4 PRODUCT TRANSPORTATION**

Carbon dioxide is emitted during the combustion of fuels used to transport refinery products. Using the same four modes of transportation associated with crude transport and an average specific gravity for the six identified petroleum products, emissions factors were derived as a function of total U.S. petroleum product consumption (see Table 3-1).

#### **5.5 END USES**

There are four major end use categories for petroleum products: heating fuels, fuels for power generation, transportation fuels, and petrochemical feedstocks. Carbon dioxide emissions predominately result from the combustion of the fuel for transportation,

heating, and power generation. Assuming complete combustion, the following CO<sub>2</sub> emission factors were calculated for the end use activities based the volume of fuel combusted:

<u>Fuel Type</u>	<u>Pounds of CO<sub>2</sub> per Barrel of Fuel</u>
Gasoline	818.3
Distilled Fuel	963.2
Kerosene	934.5
Jet Fuel*	934.5
Residual Fuel Oil	1,045.0
LPG	540.0

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\* For the purpose of estimating global CO<sub>2</sub> emissions from petroleum product combustion, jet fuel was assumed to have an emission factor identical to that of kerosene.

## 5.6 CARBON DIOXIDE EMISSIONS SCALING FACTORS

Where possible and applicable, scaling factors were developed to represent greater emissions from less developed countries. The emission factors presented in this study were developed based upon U.S. operating practices and environmental controls. However, the level of energy efficiency and environmental control is generally accepted to be much higher in the United States and other industrialized countries as compared to less developed countries. A literature search was performed to obtain CO<sub>2</sub> emission data for countries other than the United States. Collection of CO<sub>2</sub> emission data for less developed countries and subsequent development of scaling factors for each petroleum activity included in the scope of this analysis were planned. However, due to the absence of available CO<sub>2</sub> emissions data for less developed countries, no scaling factors could be quantified. Therefore, the U.S. CO<sub>2</sub> emission factors were applied to all nations. These factors may underestimate emissions of CO<sub>2</sub> worldwide.



## **6.0 CARBON DIOXIDE EMISSIONS FROM PETROLEUM SOURCES**

Based on data from 1987 through 1989, activities related to the petroleum industry result in 9.2 billion tons (8.3 billion metric tons) of CO<sub>2</sub> emissions annually. Table 6-1 presents CO<sub>2</sub> emissions by industry segment and by geographic region. Approximately 91 percent of emissions can be attributed to the end use of petroleum products. Crude oil refining accounts for slightly less than 6 percent of CO<sub>2</sub> emissions, exploration/extraction accounts for approximately 2 percent, and crude and product transport combined account for less than 1 percent. Industry activity results are represented in Figure 6-1.

Figure 6-2 illustrates the proportion of CO<sub>2</sub> emissions from petroleum sources by geographic region. The United States accounts for 26 percent of CO<sub>2</sub> emissions from all petroleum sources, the largest share of any region. Western Europe, the Far East and Oceania, and Eastern Europe including the Soviet Union emit 20 percent, 18.6 percent, and 17.1 percent, respectively. The other regions of the world combined account for the remaining 18.3 percent of CO<sub>2</sub> emissions from petroleum sources. The lack of data from some smaller nations suggests that estimated percentages may be slightly higher than actual values since total global emissions may be slightly underestimated.

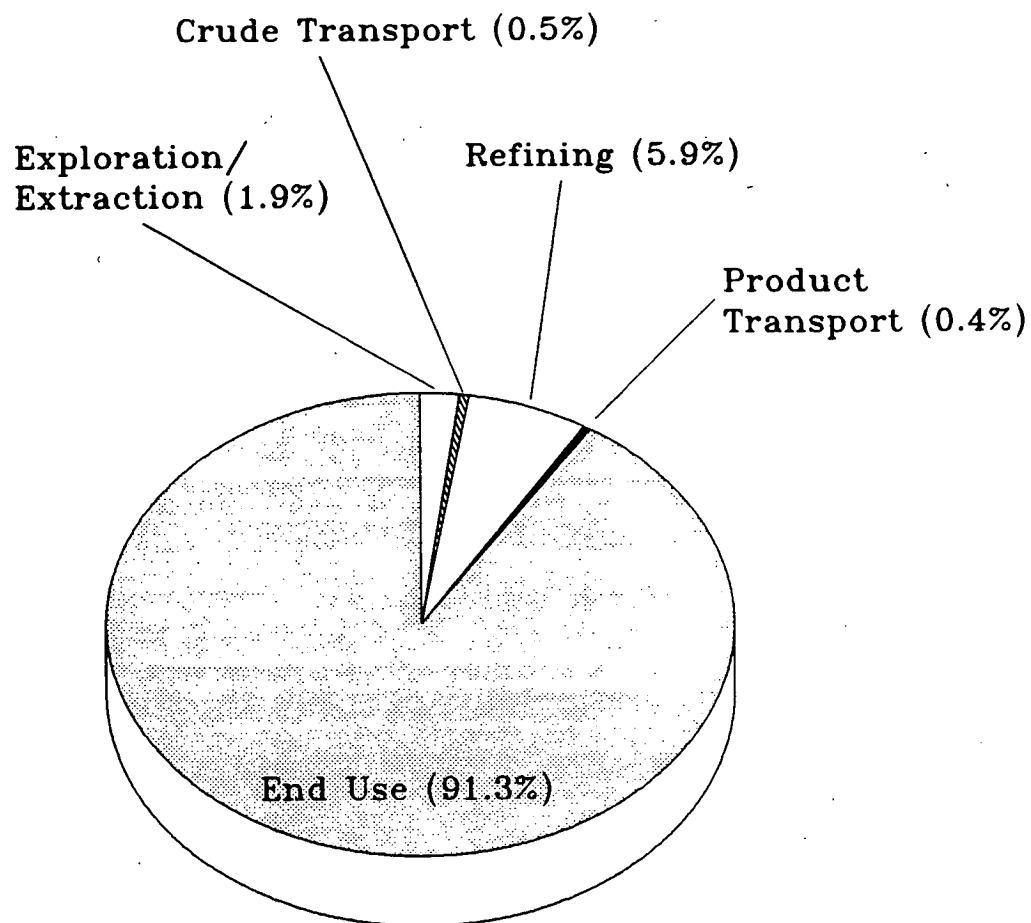
In the United States, end uses of petroleum products result in 88.1 percent of all CO<sub>2</sub> emissions from petroleum sources. All other petroleum industry segments including refining, exploration and extraction, and crude and product transport, result in 7.6 percent, 3.4 percent, and 0.9 percent of U.S. emissions, respectively (Figure 6-3).

The results of this study compare well with other research. Several estimations of global CO<sub>2</sub> emissions from anthropogenic sources have been conducted including

TABLE 6-1. CO<sub>2</sub> EMISSIONS ESTIMATES – REGIONAL SUMMARIES

Region	Exploration/ Extraction (tons/year)	Crude Transport (tons/year)	Refining (tons/year)	Product Transport (tons/year)	End Use (tons/year)	Total (tons/year)
United States	82,543,576	11,410,659	182,537,859	9,684,800	2,112,771,763	2,398,948,657
Other North America	21,669,526	2,104,787	14,352,103	1,718,042	391,185,310	431,029,768
Central and South America	14,611,123	2,441,566	47,487,938	2,151,788	498,404,357	565,096,772
Western Europe	13,708,345	8,306,885	130,311,505	7,277,364	1,687,293,403	1,846,897,502
Eastern Europe and the USSR	513,082	7,429,027	44,253,200	6,418,791	1,522,916,162	1,581,530,262
Middle East	9,932,440	1,643,993	29,892,316	1,502,305	356,189,358	399,160,412
Africa	9,339,661	1,250,300	13,484,328	1,186,566	274,831,453	300,092,308
Far East and Oceania	27,818,137	8,300,064	86,481,141	6,876,622	1,593,899,771	1,723,375,735
TOTAL	180,135,890	42,887,281	548,800,390	36,816,278	8,437,491,577	9,246,131,416





**Figure 6-1: Annual global CO<sub>2</sub> emissions from petroleum by activity.**

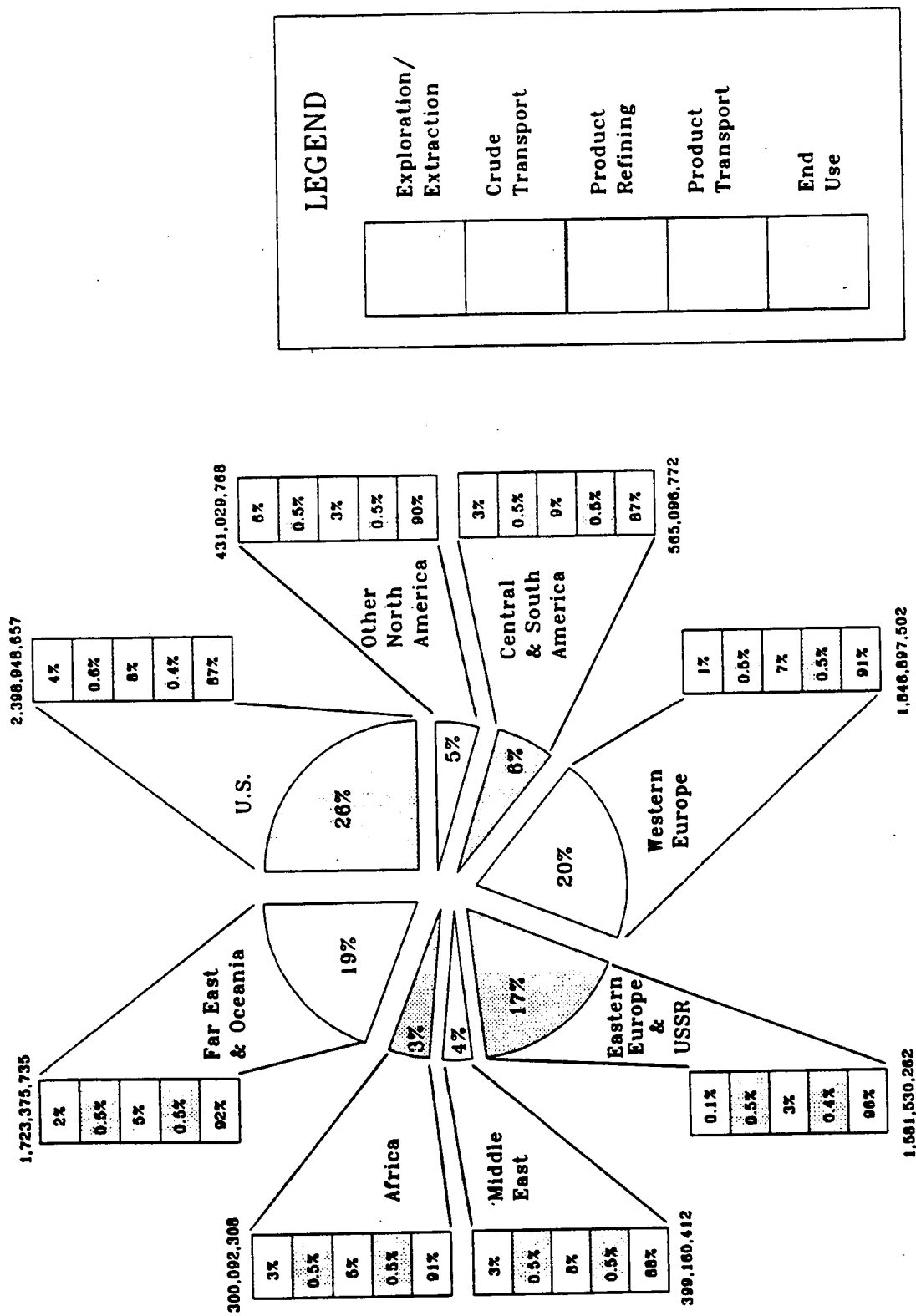
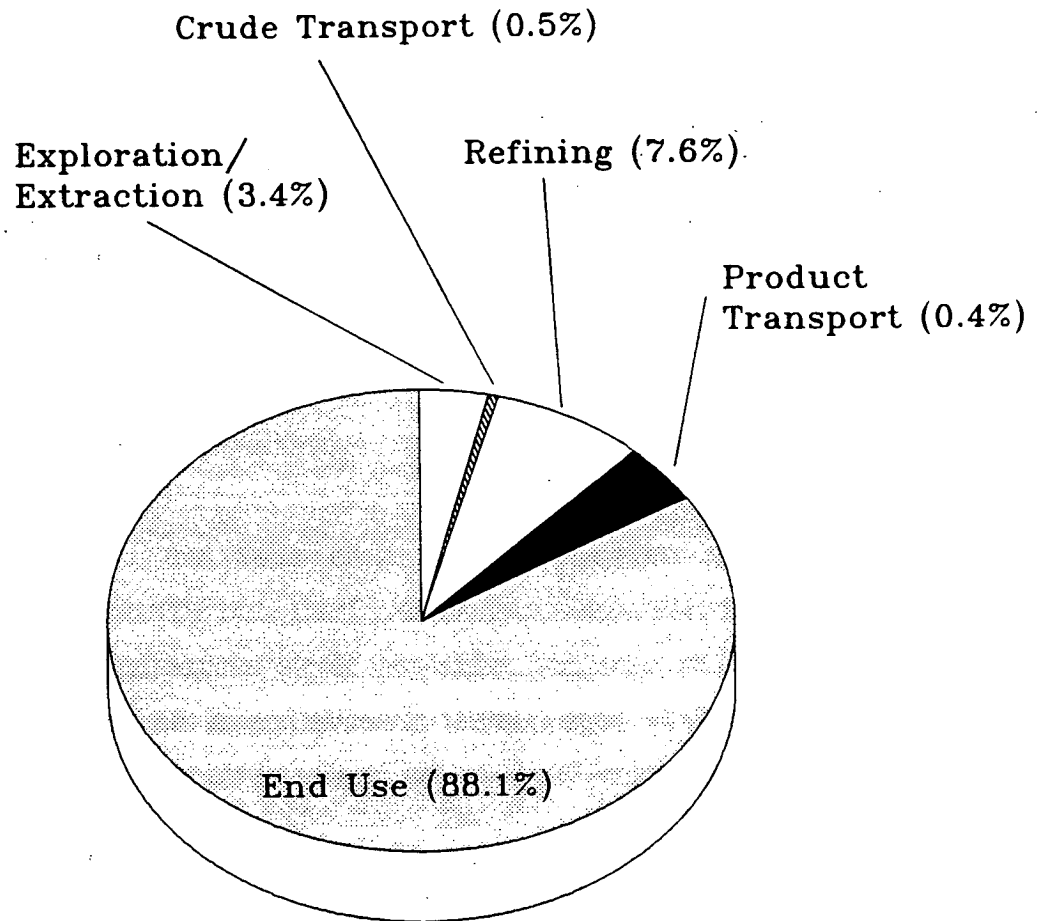


Figure 6-2. Breakdown of regional CO<sub>2</sub> emissions by industry segment. Global CO<sub>2</sub> emissions estimated at 9,246,131,416 tons per year.



**Figure 6-3: Annual U.S. CO<sub>2</sub> emissions from petroleum by activity.**

inventories and economic models. A summary of these studies as they relate to the petroleum industry is presented in Table 6-2.

The emissions database prepared for the American Petroleum Institute consists of five dBASE III Plus files, one file for each industry segment. Each file contains activity, emission factor, and emissions data for all countries where data were available. Carbon dioxide emissions by source category, country, and region are listed in Appendix A (Table A-1).

## **6.1 EXPLORATION AND EXTRACTION**

Emissions of CO<sub>2</sub> from exploration and extraction of oil and natural gas result in 2 percent of overall CO<sub>2</sub> emissions from petroleum sources (see Figure 6-1). The data for this category are incomplete because in some cases data from the Soviet Union and other Communist countries were not available. The United States accounts for 46 percent of the emissions from this category, the largest single emitter by country or region. This is due to the comparatively large number of active rigs in the United States. However, these data may be misleading because the quality of data for other regions is not as accurate or complete.

Within the exploration and extraction source category, exploration results in the vast majority of global emissions with 176 million tons of CO<sub>2</sub> annually versus 3.2 million tons of CO<sub>2</sub> annually from extraction (see Appendix A, Table A-2).

TABLE 6-2. SUMMARY OF RELATED STUDIES

Study	Global CO <sub>2</sub> Emissions from Petroleum Sources Billion tons CO <sub>2</sub> /yr	U.S. CO <sub>2</sub> Emissions from Petroleum Sources Billion tons CO <sub>2</sub> /yr	Type	Year of Analysis
Radian 1990	9.2	2.4	Inventory	1987-1989 Data
Marland et al.	8.26	1.9	Inventory	1987
Edmonds and Riley	8.9	-	Economic model	1987 Projection
Radian 1989	-	>3.0 <sup>1</sup>	Inventory	1987 Data
Lashof and Tirpak	8.1	-	Compilation of existing research	1987

<sup>1</sup> Includes the petroleum and natural gas industries, incomplete inventory.

## **6.2 CRUDE TRANSPORTATION**

Crude transport accounts for 43 million tons of CO<sub>2</sub> emissions globally (see Table 6-1). Pipeline transport results in 70 percent of these emissions, marine transport in 29 percent, trucks in 1 percent, and rail in well under 1 percent (see Appendix A, Table A-3).

## **6.3 REFINING OPERATIONS**

Petroleum refining processes account for 6.3 percent of global CO<sub>2</sub> emissions. Within the refining category, significant CO<sub>2</sub> sources are production processes with either large throughput or those that require a large amount of process heat. Atmospheric distillation was the largest single source with 190 million tons of CO<sub>2</sub> emitted annually. Other significant emission sources include thermal processes, 142 million tons of CO<sub>2</sub>; catalytic hydrotreating, 61 million tons of CO<sub>2</sub>; vacuum distillation, 54 million tons of CO<sub>2</sub>; and catalytic hydrotreating, 35 million tons (see Appendix A, Tables A-4a and A-4b).

## **6.4 PRODUCT TRANSPORTATION**

Product transport results in 37 million tons of CO<sub>2</sub> emissions globally. Pipeline transport results in 57.3 percent of these emissions, marine transport in 12.4 percent, trucks in 24.7 percent, and rail in 4.9 percent of product transport CO<sub>2</sub> emissions (see Appendix A, Table A-5). Trucks represent the most energy-inefficient mode of transport. While producing nearly 25 percent of product transport CO<sub>2</sub> emissions, trucks account for only 7 percent of total product transport in barrel-miles.

## **6.5 END USES**

The end use of petroleum products accounts for 8.4 billion tons of CO<sub>2</sub> emissions annually, 91 percent of all petroleum-related CO<sub>2</sub> emissions. The United States is responsible for 25 percent of these emissions; Western Europe, 20 percent; the Far East, 18.9 percent; and Eastern Europe, 18 percent.

Gasoline accounts for 2.45 billion tons of CO<sub>2</sub> emissions, 29 percent of all end use emissions; diesel fuel for 2.67 billion tons of CO<sub>2</sub>, 31.5 percent; residual fuel oil use for 2.3 billion tons of CO<sub>2</sub> emissions, 28.2 percent; kerosene for 0.3 billion tons of CO<sub>2</sub>, 3.6 percent; jet fuel for 0.5 billion tons of CO<sub>2</sub>, 6.4 percent; and LPG for the remaining 0.1 billion tons of CO<sub>2</sub>, 1.1 percent of annual global CO<sub>2</sub> emissions from end uses (see Appendix A, Table A-6).





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## **APPENDIX A**

### **EMISSIONS ESTIMATES BY COUNTRY, REGION, AND EMISSION SOURCES**



TABLE A-1. WORLD PETROLEUM INDUSTRY CO<sub>2</sub> EMISSIONS ESTIMATES

Country	Exploration/ Extraction (tons/year)	Crude Transport (tons/year)	Refining (tons/year)	Product Transport (tons/year)	End Use (tons/year)
<b>** Region: North America</b>					
Canada	12,110,000	1,060,000	2,892,000	879,000	195,225,000
Mexico	9,559,000	1,041,000	11,460,000	834,000	194,747,000
Other North American		4,000		5,000	1,214,000
United States of America	82,544,000	11,411,000	182,538,000	9,685,000	2,112,772,000
<b>** Subtotal **</b>	<b>104,213,000</b>	<b>13,516,000</b>	<b>196,890,000</b>	<b>11,403,000</b>	<b>2,503,958,000</b>
<b>** Region: Central and South America</b>					
Argentina	5,085,000	328,000	6,596,000	291,000	67,591,000
Bahamas		12,000		12,000	2,847,000
Barbados			8,000		
Bolivia	527,000		202,000	10,000	2,437,000
Brazil	2,571,000	906,000	8,144,000	740,000	169,835,000
Chile	434,000	71,000	1,250,000	62,000	14,287,000
Colombia	1,387,000	127,000	2,944,000	119,000	25,887,000
Costa Rica			224,000		
Cuba		150,000	748,000	148,000	35,784,000
Dominican Republic			182,000	27,000	6,404,000
Ecuador	483,000	62,000	1,094,000	58,000	13,403,000

TABLE A-1. (Continued)

Country	Exploration/ Extraction (tons/year)	Crude Transport (tons/year)	Refining (tons/year)	Product Transport (tons/year)	End Use (tons/year)
Guatemala			54,000	15,000	3,412,000
Jamaica			137,000	24,000	5,801,000
Netherlands		48,000	3,506,000	43,000	11,037,000
Antilles and Aruba					
Other Central, South American	17,000	185,000		85,000	19,687,000
Panama		21,000	378,000	19,000	4,709,000
Peru	899,000	94,000	628,000	94,000	21,922,000
Puerto Rico		111,000	737,000	103,000	23,844,000
Suriname					
Trinidad and Tobago	583,000	14,000	2,780,000	12,000	2,991,000
United States Virgin Islands		38,000	5,818,000	27,000	7,299,000
Uruguay			142,000	18,000	4,239,000
Venezuela	2,624,000	277,000	11,916,000	243,000	54,988,000
** Subtotal **	14,610,000	2,444,000	47,488,000	2,150,000	498,404,000

TABLE A-1. (Continued)

Country	Exploration/ Extraction (tons/year)	Crude Transport (tons/year)	Refining (tons/year)	Product Transport (tons/year)	End Use (tons/year)
<b>** Region: Western Europe</b>					
Austria	206,000	149,000	2,128,000	133,000	30,615,000
Belgium		309,000	6,605,000	273,000	64,764,000
Denmark	185,000	147,000	2,856,000	145,000	33,849,000
Finland		155,000	3,339,000	136,000	31,860,000
France	640,000	1,225,000	15,912,000	1,011,000	231,696,000
Germany, Federal Republic of	758,000	1,660,000	19,578,000	1,531,000	348,537,000
Greece	92,000	183,000	3,398,000	183,000	43,244,000
Ireland		55,000	221,000	55,000	12,841,000
Italy	2,062,000	1,270,000	26,715,000	1,158,000	276,829,000
Luxembourg		18,000		19,000	4,408,000
Netherlands	1,127,000	470,000	12,018,000	329,000	78,774,000
Norway	1,147,000	143,000	3,265,000	109,000	24,978,000
Other Western Europe	29,000	20,000		20,000	4,804,000
Portugal		143,000	1,739,000	106,000	25,547,000
Spain	248,000	615,000	11,781,000	483,000	113,285,000
Sweden		253,000	4,247,000	240,000	55,684,000
Switzerland and Liechtenstein		179,000	1,130,000	182,000	40,892,000

TABLE A-1. (Continued)

Country	Exploration/ Extraction (tons/year)	Crude Transport (tons/year)	Refining (tons/year)	Product Transport (tons/year)	End Use (tons/year)
United Kingdom	4,236,000	1,098,000	11,622,000	965,000	217,699,000
Yugoslavia	2,978,000	214,000	3,758,000	197,000	46,988,000
** Subtotal **	13,708,000	8,306,000	130,312,000	7,275,000	1,687,294,000
<b>** Region: Eastern Europe and U.S.S.R.</b>					
Albania		23,000	107,000	19,000	4,680,000
Bulgaria		188,000	802,000	193,000	46,578,000
Czechoslovakia		219,000	1,216,000	199,000	47,908,000
German Democratic Republic		234,000	4,369,000	223,000	52,039,000
Hungary		139,000	1,546,000	117,000	27,349,000
Poland		233,000	1,700,000	201,000	46,187,000
Romania		233,000	1,649,000	190,000	45,955,000
Union of Soviet Socialist Republics	513,000	6,159,000	32,866,000	5,278,000	1,252,220,000
** Subtotal **	513,000	7,428,000	44,255,000	6,420,000	1,522,916,000
<b>** Region: Middle East</b>					
Bahrain	1,000	13,000	2,206,000	12,000	3,001,000
Cyprus			75,000	17,000	3,940,000
Iraq	2,359,000	195,000	2,178,000	177,000	41,304,000



TABLE A-1. (Continued)

Country	Exploration/ Extraction (tons/year)	Crude Transport (tons/year)	Refining (tons/year)	Product Transport (tons/year)	End Use (tons/year)
Israel		97,000	3,029,000	89,000	21,255,000
Jordan	260,000		390,000	43,000	10,286,000
Kuwait	371,000	79,000	7,721,000	69,000	17,025,000
Lebanon			222,000	32,000	7,467,000
Neutral Zone	2,000				
Oman	1,205,000		253,000		
Other Middle East	121,000	137,000		64,000	14,771,000
Qatar	307,000		309,000		
Saudi Arabia	481,000	606,000	6,715,000	511,000	120,239,000
Syria	2,212,000	123,000	2,138,000	114,000	27,305,000
Turkey	1,833,000	308,000	3,046,000	258,000	61,748,000
United Arab Emirates	587,000	86,000	1,095,000	90,000	21,264,000
Yemen	194,000		28,000		
Yemen, People's Democratic Republic of			488,000	27,000	6,584,000
** Subtotal **	9,933,000	1,644,000	29,893,000	1,503,000	356,189,000

TABLE A-1. (Continued)

Country	Exploration/ Extraction (tons/year)	Crude Transport (tons/year)	Refining (tons/year)	Product Transport (tons/year)	End Use (tons/year)
<b>** Region: Africa</b>					
Algeria	2,220,000	114,000	1,379,000	86,000	19,770,000
Angola and Cabinda	758,000	16,000	124,000	17,000	3,985,000
Benin					
Cameroon	1,000		223,000		
Congo	111,000		96,000		
Egypt	1,684,000	303,000	2,089,000	288,000	69,371,000
Gabon	547,000		262,000		
Ghana			86,000		
Ivory Coast			513,000	25,000	5,779,000
Kenya	231,000	24,000	317,000	23,000	5,512,000
Libya	1,564,000	92,000	977,000	92,000	21,902,000
Morocco		63,000	599,000	55,000	13,334,000
Mozambique				6,000	
Nigeria	1,316,000	149,000	2,127,000	144,000	32,204,000
Other Africa	352,000	217,000		167,000	37,896,000
South Africa	277,000	236,000	4,454,000	216,000	49,426,000
Customs Union					

TABLE A-1. (Continued)

Country	Exploration/ Extraction (tons/year)	Crude Transport (tons/year)	Refining (tons/year)	Product Transport (tons/year)	End Use (tons/year)
Sudan			87,000	19,000	4,550,000
Tunisia	278,000	36,000	93,000	34,000	8,000,000
Zaire			57,000	13,000	3,101,000
** Subtotal **	9,339,000	1,250,000	13,483,000	1,185,000	274,830,000
<b>** Region: Far East and Oceania</b>					
Australia	1,314,000	440,000	4,248,000	393,000	86,169,000
Bangladesh	462,000		119,000		
Brunei Darussalam	372,000		27,000		
Burma	2,127,000		236,000	10,000	2,225,000
China (Mainland)	155,000	1,421,000	5,878,000	1,231,000	291,870,000
China (Taiwan)	387,000	288,000	4,003,000	217,000	43,136,000
Guam				4,000	821,000
Hong Kong		73,000		70,000	16,788,000
India	12,509,000	676,000	7,452,000	595,000	140,600,000
Indonesia	4,242,000	338,000	5,558,000	344,000	79,806,000
Iran	1,803,000	531,000	4,791,000	517,000	121,153,000
Japan	510,000	3,070,000	35,405,000	2,141,000	500,365,000
Korea, North			112,000	51,000	11,556,000

TABLE A-1. (Continued)

Country	Exploration/ Extraction (tons/year)	Crude Transport (tons/year)	Refining (tons/year)	Product Transport (tons/year)	End Use (tons/year)
Korea, South		438,000	4,469,000	345,000	84,045,000
Malaysia	1,073,000	135,000	741,000	133,000	30,743,000
New Zealand	156,000	64,000	623,000	55,000	
Other Far East	75,000	202,000		100,000	23,015,000
Pakistan	1,230,000	123,000	451,000	129,000	30,267,000
Papua New Guinea	277,000				
Philippines	601,000	129,000	1,471,000	130,000	31,155,000
Singapore		195,000	8,913,000	196,000	49,550,000
Sri Lanka			520,000	25,000	5,926,000
Thailand	526,000	177,000	1,464,000	171,000	39,681,000
Vietnam				22,000	5,031,000
** Subtotal **	27,819,000	8,300,000	86,481,000	6,879,000	1,593,902,000
*** Total ***	180,135,000	42,888,000	548,802,000	36,815,000	8,437,493,000

TABLE A-2. WORLD PETROLEUM INDUSTRY DRILLING/EXTRACTION CO<sub>2</sub> EMISSIONS ESTIMATES

Country	Drilling (tons/year)	Extraction (tons/year)
<b>** Region: North America</b>		
Canada	11,974,000	136,000
Mexico	9,546,000	13,000
Other North American		
United States of America	80,376,000	2,157,000
<b>** Subtotal **</b>	<b>101,886,000</b>	<b>2,317,000</b>
<b>** Region: Central and South America</b>		
Argentina	5,053,000	32,000
Bahamas		
Barbados		
Bolivia	526,000	1,000
Brazil	2,550,000	22,000
Chile	433,000	1,000
Colombia	1,377,000	10,000
Costa Rica		
Cuba		
Dominican Republic		
Ecuador	479,000	3,000
Guatemala		
Jamaica		
Netherlands		
Antilles and Aruba		
Other Central/South American	17,000	
Panama		
Peru	886,000	12,000
Puerto Rico		
Suriname		

TABLE A-2. (Continued)

Country	Drilling (tons/year)	Extraction (tons/year)
Trinidad and Tobago	572,000	12,000
United States Virgin Islands		
Uruguay		
Venezuela	2,578,000	45,000
<b>** Subtotal **</b>	<b>14,472,000</b>	<b>139,000</b>
<b>** Region: Western Europe</b>		
Austria	202,000	3,000
Belgium		
Denmark	185,000	
Finland		
France	638,000	2,000
Germany, Federal Republic of	748,000	10,000
Greece	92,000	
Ireland		
Italy	2,062,000	1,000
Luxembourg		
Netherlands	1,126,000	1,000
Norway	1,146,000	1,000
Other Western Europe	29,000	
Portugal		
Spain	248,000	
Sweden		
Switzerland and Liechtenstein		
United Kingdom	4,233,000	3,000
Yugoslavia	2,974,000	4,000
<b>** Subtotal **</b>	<b>13,683,000</b>	<b>25,000</b>

TABLE A-2. (Continued)

Country	Drilling (tons/year)	Extraction (tons/year)
<b>** Region: Eastern Europe and U.S.S.R.</b>		
Albania		
Bulgaria		
Czechoslovakia		
German Democratic Republic		
Hungary		
Poland		
Romania		
Union of Soviet Socialist Republics		513,000
<b>** Subtotal **</b>	0	513,000
<b>** Region: Middle East</b>		
Bahrain		1,000
Cyprus		
Iraq	2,356,000	3,000
Israel		
Jordan	260,000	
Kuwait	370,000	1,000
Lebanon		
Neutral Zone		2,000
Oman	1,201,000	4,000
Other Middle East	121,000	
Qatar	306,000	1,000
Saudi Arabia	479,000	2,000
Syria	2,209,000	3,000
Turkey	1,831,000	2,000
United Arab Emirates	583,000	4,000

TABLE A-2. (Continued)

Country	Drilling (tons/year)	Extraction (tons/year)
Yemen	193,000	
Yemen, People's Democratic Republic of		
<b>** Subtotal **</b>	<b>9,910,000</b>	<b>23,000</b>
<b>** Region: Africa</b>		
Algeria	2,218,000	3,000
Angola and Cabinda	756,000	1,000
Benin		
Cameroon		1,000
Congo	110,000	1,000
Egypt	1,680,000	3,000
Gabon	546,000	1,000
Ghana		
Ivory Coast		
Kenya	231,000	
Libya	1,562,000	2,000
Morocco		
Mozambique		
Nigeria	1,311,000	5,000
Other Africa	352,000	
South Africa Customs Union	277,000	
Sudan		
Tunisia	277,000	1,000
Zaire		
<b>** Subtotal **</b>	<b>9,321,000</b>	<b>19,000</b>
<b>** Region: Far East and Oceania</b>		
Australia	1,311,000	3,000



TABLE A-2. (Continued)

Country	Drilling (tons/year)	Extraction (tons/year)
Bangladesh	462,000	
Brunei Darussalam	370,000	2,000
Burma	2,125,000	2,000
China (Mainland)		155,000
China (Taiwan)	387,000	
Guam		
Hong Kong		
India	12,502,000	7,000
Indonesia	4,242,000	
Iran	1,802,000	1,000
Japan	508,000	1,000
Korea, North		
Korea, South		
Malaysia	1,071,000	2,000
New Zealand	156,000	
Other Far East	75,000	
Pakistan	1,230,000	
Papua New Guinea	277,000	
Philippines	601,000	
Singapore		
Sri Lanka		
Thailand	526,000	1,000
Vietnam		
** Subtotal **	27,644,000	174,000
*** Total ***	176,925,000	3,211,000

TABLE A-3. WORLD PETROLEUM INDUSTRY CRUDE TRANSPORTATION CO<sub>2</sub> EMISSIONS ESTIMATE

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
<b>** Region: North America</b>				
Canada	306,000	740,000	12,000	3,000
Mexico	300,000	727,000	11,000	3,000
Other North American	1,000	3,000		
United States of America	3,289,000	7,967,000	126,000	29,000
<b>** Subtotal **</b>	<b>3,896,000</b>	<b>9,436,000</b>	<b>149,000</b>	<b>35,000</b>
<b>** Region: Central and South America</b>				
Argentina	95,000	229,000	4,000	1,000
Bahamas	3,000	8,000		
Barbados				
Bolivia				
Brazil	261,000	632,000	10,000	2,000
Chile	20,000	49,000	1,000	
Colombia	37,000	88,000	1,000	
Costa Rica				
Cuba	43,000	105,000	2,000	
Dominican Republic				
Ecuador	18,000	43,000	1,000	
Guatemala				
Jamaica				
Netherlands	14,000	33,000	1,000	
Antilles and Aruba				
Other Central/South American	53,000	129,000	2,000	
Panama	6,000	14,000		
Peru	27,000	66,000	1,000	
Puerto Rico	32,000	77,000	1,000	

TABLE A-3. (Continued)

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
Suriname				
Trinidad and Tobago	4,000	10,000		
United States Virgin Islands	11,000	26,000		
Uruguay				
Venezuela	80,000	193,000	3,000	1,000
<b>** Subtotal **</b>	<b>704,000</b>	<b>1,705,000</b>	<b>27,000</b>	<b>6,000</b>
<b>** Region: Western Europe</b>				
Austria	43,000	104,000	2,000	
Belgium	89,000	216,000	3,000	1,000
Denmark	42,000	103,000	2,000	
Finland	45,000	108,000	2,000	
France	353,000	855,000	14,000	3,000
Germany, Federal Republic of	478,000	1,159,000	18,000	4,000
Greece	53,000	128,000	2,000	
Ireland	16,000	39,000	1,000	
Italy	366,000	887,000	14,000	3,000
Luxembourg	5,000	13,000		
Netherlands	135,000	328,000	5,000	1,000
Norway	41,000	100,000	2,000	
Other Western Europe	6,000	14,000		
Portugal	41,000	100,000	2,000	
Spain	177,000	429,000	7,000	2,000
Sweden	73,000	177,000	3,000	1,000
Switzerland and Liechtenstein	52,000	125,000	2,000	
United Kingdom	316,000	766,000	12,000	3,000
Yugoslavia	62,000	150,000	2,000	1,000
<b>** Subtotal **</b>	<b>2,395,000</b>	<b>5,800,000</b>	<b>92,000</b>	<b>21,000</b>

TABLE A-3. (Continued)

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
<b>** Region: Eastern Europe and U.S.S.R:</b>				
Albania	7,000	16,000		
Bulgaria	54,000	131,000	2,000	
Czechoslovakia	63,000	153,000	2,000	1,000
German Democratic Republic	68,000	164,000	3,000	1,000
Hungary	40,000	97,000	2,000	
Poland	67,000	163,000	3,000	1,000
Romania	67,000	163,000	3,000	1,000
Union of Soviet Socialist Republics	1,775,000	4,300,000	68,000	16,000
<b>** Subtotal **</b>	<b>2,142,000</b>	<b>5,187,000</b>	<b>82,000</b>	<b>19,000</b>
<b>** Region: Middle East</b>				
Bahrain	4,000	9,000		
Cyprus				
Iraq	56,000	136,000	2,000	
Israel	28,000	67,000	1,000	
Jordan				
Kuwait	23,000	55,000	1,000	
Lebanon				
Neutral Zone				
Oman				
Other Middle East	39,000	96,000	2,000	
Qatar				
Saudi Arabia	175,000	423,000	7,000	2,000
Syria	36,000	86,000	1,000	
Turkey	89,000	215,000	3,000	1,000
United Arab Emirates	25,000	60,000	1,000	

TABLE A-3. (Continued)

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
Yemen				
Yemen, People's Democratic Republic of				
<b>** Subtotal **</b>	<b>474,000</b>	<b>1,148,000</b>	<b>18,000</b>	<b>4,000</b>
<b>** Region: Africa</b>				
Algeria	33,000	80,000	1,000	
Angola and Cabinda	5,000	11,000		
Benin				
Cameroon				
Congo				
Egypt	87,000	211,000	3,000	1,000
Gabon				
Ghana				
Ivory Coast				
Kenya	7,000	17,000		
Libya	26,000	64,000	1,000	
Morocco	18,000	44,000	1,000	
Mozambique				
Nigeria	43,000	104,000	2,000	
Other Africa	63,000	152,000	2,000	1,000
South Africa	68,000	165,000	3,000	1,000
Customs Union				
Sudan				
Tunisia	10,000	25,000		
Zaire				
<b>** Subtotal **</b>	<b>360,000</b>	<b>873,000</b>	<b>14,000</b>	<b>3,000</b>

TABLE A-3. (Continued)

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
<b>** Region: Far East and Oceania</b>				
Australia	127,000	307,000	5,000	1,000
Bangladesh				
Brunei Darussalam				
Burma				
China (Mainland)	410,000	992,000	16,000	4,000
China (Taiwan)	83,000	201,000	3,000	1,000
Guam				
Hong Kong	21,000	51,000	1,000	
India	195,000	472,000	7,000	2,000
Indonesia	97,000	236,000	4,000	1,000
Iran	153,000	370,000	6,000	1,000
Japan	885,000	2,144,000	34,000	8,000
Korea, North				
Korea, South	126,000	305,000	5,000	1,000
Malaysia	39,000	94,000	1,000	
New Zealand	19,000	45,000	1,000	
Other Far East	58,000	141,000	2,000	1,000
Pakistan	36,000	86,000	1,000	
Papua New Guinea				
Philippines	37,000	90,000	1,000	
Singapore	56,000	136,000	2,000	
Sri Lanka				
Thailand	51,000	124,000	2,000	
Vietnam				
<b>** Subtotal **</b>	<b>2,393,000</b>	<b>5,795,000</b>	<b>92,000</b>	<b>21,000</b>
<b>*** Total ***</b>	<b>12,363,000</b>	<b>29,943,000</b>	<b>473,000</b>	<b>109,000</b>

TABLE A-4a. WORLD PETROLEUM INDUSTRY REFINERY CO<sub>2</sub> EMISSIONS ESTIMATES

Country	Atmospheric Distillation (tons/year)	Flaring (tons/year)	Vacuum Distillation (tons/year)	Thermal Processes (tons/year)	Cat Cracking (tons/year)	Cat Reforming (tons/year)	Cat Hydrocracking (tons/year)
<b>** Region: North America</b>							
Canada	1,061,000	5,000	297,000	187,000	244,000	35,000	312,000
Mexico	4,028,000	18,000	1,811,000	2,160,000	710,000	84,000	96,000
Other North American							
United States of America	41,057,000	182,000	18,753,000	51,944,000	15,065,000	2,059,000	6,452,000
<b>** Subtotal **</b>	<b>46,146,000</b>	<b>205,000</b>	<b>20,861,000</b>	<b>54,291,000</b>	<b>16,019,000</b>	<b>2,178,000</b>	<b>6,860,000</b>
<b>** Region: Central and South America</b>							
Argentina	1,832,000	8,000	690,000	3,324,000	332,000	22,000	127,000
Bahamas							
Barbados	8,000						
Bolivia	153,000	1,000	8,000			8,000	
Brazil	3,741,000	17,000	1,993,000	1,009,000	881,000	11,000	
Chile	391,000	2,000	198,000	527,000	103,000	5,000	
Colombia	605,000	3,000	319,000	1,580,000	242,000	3,000	
Costa Rica	43,000		2,000	171,000		1,000	
Cuba	745,000	3,000					
Dominican Republic	129,000	1,000				5,000	
Ecuador	386,000	2,000	106,000	556,000	43,000	1,000	
Guatemala	43,000					2,000	

TABLE A-4a. (Continued)

Country	Atmospheric Distillation (tons/year)	Flaring (tons/year)	Vacuum Distillation (tons/year)	Thermal Processes (tons/year)	Cat Cracking (tons/year)	Cat Reforming (tons/year)	Cat Hydrocracking (tons/year)
Jamaica	91,000		5,000			2,000	
Netherlands Antilles and Aruba	851,000	4,000	420,000	1,764,000	112,000	8,000	
Other Central/South American							
Panama	266,000	1,000	37,000			4,000	
Peru	459,000	2,000	98,000		60,000	1,000	
Puerto Rico	327,000	1,000	181,000		36,000	14,000	80,000
Suriname							
Trinidad and Tobago	798,000	4,000	455,000	474,000	74,000	16,000	
United States Virgin Islands	1,450,000	6,000	572,000	2,107,000		66,000	
Uruguay	88,000		35,000		11,000	1,000	
Venezuela	3,195,000	14,000	1,491,000	3,634,000	514,000	3,000	
** Subtotal **	15,599,000	69,000	6,611,000	15,146,000	2,407,000	174,000	207,000
** Region: Western Europe							
Austria	543,000	2,000	181,000	617,000	64,000	17,000	41,000
Belgium	1,733,000	8,000	794,000	1,654,000	279,000	43,000	
Denmark	496,000	2,000	109,000	1,940,000		17,000	
Finland	641,000	3,000	217,000	1,219,000	111,000	23,000	76,000
France	4,841,000	21,000	1,757,000	4,581,000	938,000	132,000	72,000



TABLE A-4a. (Continued)

Country	Atmospheric Distillation (tons/year)	Flaring (tons/year)	Vacuum Distillation (tons/year)	Thermal Processes (tons/year)	Cat Cracking (tons/year)	Cat Reforming (tons/year)	Cat Hydrocracking (tons/year)
Germany, Federal Republic of	4,009,000	18,000	2,052,000	7,460,000	486,000	151,000	576,000
Greece	1,023,000	5,000	314,000	1,083,000	134,000	25,000	
Ireland	149,000	1,000				6,000	
Italy	7,458,000	33,000	1,829,000	10,874,000	813,000	178,000	314,000
Luxembourg							
Netherlands	3,673,000	16,000	1,076,000	4,084,000	334,000	95,000	277,000
Norway	785,000	3,000	11,000	2,002,000	109,000	24,000	
Other Western Europe							
Portugal	833,000	4,000	147,000		27,000	28,000	54,000
Spain	3,440,000	15,000	1,061,000	4,582,000	461,000	92,000	80,000
Sweden	1,137,000	5,000	359,000	1,712,000	67,000	38,000	
Switzerland and Liechtenstein	351,000	2,000	64,000	527,000		14,000	
United Kingdom	3,334,000	15,000	1,491,000	3,450,000	855,000	109,000	117,000
Yugoslavia	1,620,000	7,000	476,000	938,000	138,000	40,000	38,000
** Subtotal **	36,067,000	160,000	11,937,000	46,722,000	4,816,000	1,030,000	1,644,000

TABLE A-4a. (Continued)

Country	Atmospheric Distillation (tons/year)	Flaring (tons/year)	Vacuum Distillation (tons/year)	Thermal Processes (tons/year)	Cat Cracking (tons/year)	Cat Reforming (tons/year)	Cat Hydrocracking (tons/year)
<b>** Region: Eastern Europe and U.S.S.R.</b>							
Albania	106,000						
Bulgaria	798,000	4,000					
Czechoslovakia	1,210,000	5,000					
German Democratic Republic	2,115,000	9,000	378,000	1,093,000	96,000	23,000	
Hungary	585,000	3,000	319,000	350,000	53,000	12,000	
Poland	1,025,000	5,000	309,000		130,000	17,000	
Romania	1,641,000	7,000					
Union of Soviet Socialist Republics	32,721,000	145,000					
<b>** Subtotal **</b>	<b>40,202,000</b>	<b>178,000</b>	<b>1,006,000</b>	<b>1,443,000</b>	<b>279,000</b>	<b>51,000</b>	
<b>** Region: Middle East</b>							
Bahrain	646,000	3,000	415,000	527,000	104,000	10,000	
Cyprus	48,000		7,000			2,000	
Iraq	847,000	4,000	220,000			23,000	202,000
Israel	479,000	2,000	253,000	1,764,000	64,000	14,000	
Jordan	266,000	1,000	44,000		11,000	5,000	26,000
Kuwait	2,179,000	10,000	899,000	1,422,000	112,000	18,000	904,000

TABLE A-4a. (Continued)

Country	Atmospheric Distillation (tons/year)	Flaring (tons/year)	Vacuum Distillation (tons/year)	Thermal Processes (tons/year)	Cat Cracking (tons/year)	Cat Reforming (tons/year)	Cat Hydrocracking (tons/year)
Lebanon	98,000		34,000		19,000	4,000	
Neutral Zone							
Oman	205,000	1,000				8,000	
Other Middle East							
Qatar	165,000	1,000				6,000	
Saudi Arabia	2,679,000	12,000	1,108,000	895,000	205,000	92,000	416,000
Syria	648,000	3,000	163,000	958,000		15,000	
Turkey	1,868,000	8,000	424,000	119,000	91,000	33,000	
United Arab Emirates	479,000	2,000	122,000			16,000	144,000
Yemen	27,000					1,000	
Yemen, People's Democratic Republic of	430,000	2,000	25,000			6,000	
** Subtotal **	11,063,000	49,000	3,715,000	5,685,000	606,000	253,000	1,691,000
** Region: Africa							
Algeria	1,236,000	5,000	40,000			30,000	
Angola and Cabinda	85,000		5,000			1,000	
Benin							
Cameroon	114,000	1,000				4,000	
Congo	56,000		21,000			1,000	11,000

TABLE A-4a. (Continued)

Country	Atmospheric Distillation (tons/year)	Flaring (tons/year)	Vacuum Distillation (tons/year)	Thermal Processes (tons/year)	Cat Cracking (tons/year)	Cat Reforming (tons/year)	Cat Hydrocracking (tons/year)
Egypt	1,301,000	6,000	124,000	434,000		16,000	
Gabon	64,000			190,000		1,000	
Ghana	71,000					3,000	
Ivory Coast	184,000	1,000	100,000			7,000	76,000
Kenya	239,000	1,000	5,000			5,000	
Libya	876,000	4,000	9,000			8,000	
Morocco	411,000	2,000	73,000		15,000	14,000	
Mozambique							
Nigeria	1,153,000	5,000	331,000		220,000	37,000	
Other Africa							
South Africa Customs Union	1,153,000	5,000	277,000	1,672,000	225,000	33,000	96,000
Sudan	67,000					1,000	
Tunisia	90,000					2,000	
Zaire	45,000					2,000	
** Subtotal **	7,146,000	32,000	985,000	2,296,000	459,000	165,000	182,000

TABLE A-4a. (Continued)

Country	Atmospheric Distillation (tons/year)	Flaring (tons/year)	Vacuum Distillation (tons/year)	Thermal Processes (tons/year)	Cat Cracking (tons/year)	Cat Reforming (tons/year)	Cat Hydrocracking (tons/year)
<b>** Region: Far East and Oceania</b>							
Australia	1,796,000	8,000	422,000		518,000	87,000	
Bangladesh	83,000		9,000			1,000	
Brunei Darussalam	27,000						
Burma	85,000		11,000	137,000			
China (Mainland)	5,852,000	26,000					
China (Taiwan)	1,516,000	7,000	312,000	375,000	63,000	32,000	101,000
Guam							
Hong Kong							
India	2,870,000	13,000	889,000	2,915,000	363,000	14,000	
Indonesia	1,900,000	8,000	609,000	2,152,000	34,000	33,000	533,000
Iran	1,410,000	6,000	572,000	2,128,000		34,000	496,000
Japan	11,169,000	49,000	4,400,000	2,260,000	1,642,000	283,000	813,000
Korea, North	112,000						
Korea, South	2,306,000	10,000	222,000	1,283,000		33,000	154,000
Malaysia	557,000	2,000	31,000			13,000	
New Zealand	253,000	1,000	111,000			14,000	123,000
Other Far East							

TABLE A-4a. (Continued)

Country	Atmospheric Distillation (tons/year)	Flaring (tons/year)	Vacuum Distillation (tons/year)	Thermal Processes (tons/year)	Cat Cracking (tons/year)	Cat Reforming (tons/year)	Cat Hydrocracking (tons/year)
Pakistan	322,000	1,000	36,000			3,000	
Papua New Guinea							
Philippines	755,000	3,000	188,000		61,000	21,000	
Singapore	2,208,000	10,000	686,000	4,490,000		33,000	261,000
Sri Lanka	133,000	1,000	6,000	329,000		2,000	
Thailand	572,000	3,000	74,000	464,000	42,000	11,000	
Vietnam							
** Subtotal **	33,925,000	150,000	8,580,000	16,531,000	2,723,000	613,000	2,480,000
*** Total ***	190,149,000	843,000	53,695,000	142,115,000	27,309,000	4,465,000	13,064,000

NOTE: Values may not add up to subtotals and totals due to rounding. Emissions of less than 500 tons per year are not reported.

TABLE A-4b. WORLD PETROLEUM INDUSTRY REFINERY CO<sub>2</sub> EMISSIONS ESTIMATES

Country	Cat Hydrotreating (tons/year)	Cat Hydrotreating (tons/year)	Alkylation (tons/year)	Aromatics/ Isomerization (tons/year)	Hydrogen Processes (tons/year)	Lubes (tons/year)	Asphalt (tons/year)	Coking (tons/year)
<b>** Region: North America</b>								
Canada	120,000	363,000	218,000	165,000	1,000	14,000	35,000	1,000
Mexico	1,995,000	413,000	71,000	74,000		50,000	24,000	1,000
Other North American								
United States of America	19,241,000	14,235,000	10,871,000	7,108,000	15,000	1,039,000	1,467,000	158,000
<b>** Subtotal **</b>	<b>21,356,000</b>	<b>15,011,000</b>	<b>11,160,000</b>	<b>7,348,000</b>	<b>16,000</b>	<b>1,103,000</b>	<b>1,527,000</b>	<b>159,000</b>
<b>** Region: Central and South America</b>								
Argentina		126,000	66,000			24,000	44,000	2,000
Bahamas								
Barbados								
Bolivia		31,000				2,000		
Brazil		270,000	83,000	24,000		69,000	69,000	3,000
Chile		12,000	10,000				2,000	
Colombia		68,000	108,000	46,000		10,000	5,000	
Costa Rica		7,000					1,000	
Cuba								

TABLE A-4b. (Continued)

Country	Crude Refining (tons/year)	Crude Hydrotreating (tons/year)	Alkylation (tons/year)	Aromatics/ Isomerization (tons/year)	Hydrogen Processes (tons/year)	Lubes (tons/year)	Asphalt (tons/year)	Coking (tons/year)
Dominican Republic		47,000						
Ecuador								
Guatemala		10,000						
Jamaica		39,000						
Netherlands Antilles and Aruba		242,000	54,000			35,000	16,000	
Other Central/ South American								
Panama		60,000					10,000	
Peru						5,000	3,000	
Puerto Rico		95,000					2,000	
Suriname								
Trinidad and Tobago	834,000	83,000	25,000	25,000		12,000	4,000	
United States Virgin Islands	1,037,000	579,000		407,000				
Uruguay		7,000						
Venezuela	2,363,000		587,000	166,000	1,000	33,000	80,000	
** Subtotal **	4,234,000	1,676,000	932,000	668,000	1,116	189,000	236,000	5,000



TABLE A-4b. (Continued)

Country	Crude Hydrotreating (tons/year)	Crude Hydrotreating (tons/year)	Alkylation (tons/year)	Aromatics/ Isomerization (tons/year)	Hydrogen Processes (tons/year)	Lubricants (tons/year)	Asphalt (tons/year)	Coking (tons/year)
<b>** Region: Western Europe</b>								
Austria	543,000	98,000		81,000		10,000	12,000	
Belgium	1,605,000	364,000	74,000				51,000	
Denmark	104,000	172,000		36,000			16,000	
Finland	834,000	116,000	76,000	33,000			24,000	
France	2,154,000	1,055,000	97,000	235,000		137,000	128,000	
Germany, Federal Republic of	3,475,000	1,004,000	121,000	557,000	2,000	57,000	159,000	7,000
Greece	534,000	200,000	55,000	104,000		15,000	11,000	
Ireland	44,000	22,000						
Italy	3,003,000	1,348,000	399,000	747,000	1,000	145,000	316,000	3,000
Luxembourg								
Netherlands	1,183,000	1,089,000	110,000	54,000	1,000	50,000	31,000	
Norway		209,000	113,000	33,000			8,000	1,000
Other Western Europe								
Portugal	397,000	152,000	79,000	27,000		12,000	6,000	
Spain	1,246,000	666,000	16,000	199,000		36,000	85,000	1,000

TABLE A-4b. (Continued)

Country	Cat Hydrorefining (tons/year)	Cat Hydrotreating (tons/year)	Alkylation (tons/year)	Aromatics/ Isomerization (tons/year)	Hydrogen Processes (tons/year)	Lubes (tons/year)	Asphalt (tons/year)	Coking (tons/year)
Sweden	519,000	308,000	34,000	36,000		11,000	58,000	
Switzerland and Liechtenstein	64,000	98,000		33,000			11,000	
United Kingdom	327,000	1,238,000	504,000	503,000		74,000	103,000	5,000
Yugoslavia	175,000	215,000	33,000	167,000		21,000	55,000	
** Subtotal **	16,206,000	8,354,000	1,710,000	2,845,000	5,000	568,000	1,074,000	17,000
** Region: Eastern Europe and U.S.S.R.								
Albania								
Bulgaria								
Czechoslovakia								
German Democratic Republic	319,000	229,000	50,000	116,000		38,000	19,000	
Hungary		153,000	32,000	89,000		17,000	22,000	
Poland		141,000	42,000	113,000		32,000		
Romania								
Union of Soviet Socialist Republics								
** Subtotal **	319,000	523,000	123,000	318,000	0	87,000	41,000	0

TABLE A-4b. (Continued)

Country	Cat Hydrotreating (tons/year)	Cat Hydrotreating (tons/year)	Alkylation (tons/year)	Aromatics/ Isomerization (tons/year)	Hydrogen Processes (tons/year)	Lubes (tons/year)	Asphalt (tons/year)	Coking (tons/year)
<b>** Region: Middle East</b>								
Bahrain	399,000	80,000	12,000				10,000	
Cyprus		15,000					2,000	
Iraq	798,000	26,000				44,000	14,000	
Israel	383,000	64,000					6,000	
Jordan		30,000					8,000	
Kuwait	1,636,000	525,000			3,000		10,000	4,000
Lebanon	59,000	6,000					1,000	
Neutral Zone								
Oman		39,000						
Other Middle East								
Qatar	96,000	41,000						
Saudi Arabia	399,000	730,000	120,000	167,000	1,000		58,000	
Syria	212,000	120,000		26,000			17,000	1,000
Turkey	120,000	305,000				17,000	60,000	
United Arab Emirates	175,000	157,000						
Yemen								

TABLE A-4b. (Continued)

Country	Cat Hydrorefining (tons/year)	Cat Hydrotreating (tons/year)	Alkylation (tons/year)	Aromatics/ Isomerization (tons/year)	Hydrogen Processes (tons/year)	Lubes (tons/year)	Asphalt (tons/year)	Coking (tons/year)
Yemen, People's Democratic Republic of	22,000						4,000	
** Subtotal **	4,299,000	2,137,000	132,000	193,000	5,000	61,000	190,000	5,000
<b>** Region: Africa</b>								
Algeria		47,000		17,000		10,000	11,000	
Angola and Cabinda	22,000	8,000					2,000	
Benin								
Cameroon	85,000	19,000						
Congo		7,000						
Egypt		168,000	8,000	13,000		17,000	13,000	1,000
Gabon		7,000						
Ghana		12,000						
Ivory Coast	102,000	34,000					10,000	
Kenya		66,000					2,000	
Libya		74,000				3,000	3,000	
Morocco		71,000				9,000	4,000	
Mozambique								

TABLE A-4b. (Continued)

Country	Cat Hydrorefining (tons/year)	Cat Hydrotreating (tons/year)	Alkylation (tons/year)	Aromatics/ Isomerization (tons/year)	Hydrogen Processes (tons/year)	Lubes (tons/year)	Asphalt (tons/year)	Coking (tons/year)
Nigeria		218,000	116,000	35,000		17,000	30,000	
Other Africa								
South Africa Customs Union	617,000	284,000	67,000	85,000		13,000	12,000	
Sudan		19,000						
Tunisia								
Zaire		10,000						
** Subtotal **	827,000	1,044,000	191,000	151,000	0	69,000	88,000	1,000
** Region: Far East and Oceania								
Australia	269,000	518,000	534,000	116,000		57,000	39,000	
Bangladesh	19,000	4,000					2,000	
Brunei Darussalam								
Burma						2,000		
China (Mainland)								
China (Taiwan)	1,395,000	149,000	32,000	110,000	1,000		19,000	2,000
Guam								
Hong Kong								
India	110,000	135,000		38,000	1,000	60,000	82,000	2,000

TABLE A-4b. (Continued)

Country	Cat Hydrotreating (tons/year)	Cat Hydrorefining (tons/year)	Alkylation (tons/year)	Aromatics/ Isomerization (tons/year)	Hydrogen Processes (tons/year)	Lubes (tons/year)	Asphalt (tons/year)	Coking (tons/year)
Indonesia	144,000	103,000	6,000		1,000	22,000	15,000	
Iran	25,000	68,000				26,000	25,000	
Japan	10,207,000	3,920,000	296,000	526,000	6,000	207,000	153,000	1,000
Korea, North								
Korea, South	168,000	223,000		159,000		31,000	38,000	
Malaysia		129,000					8,000	
New Zealand		118,000					2,000	
Other Far East								
Pakistan		67,000		5,000		15,000	8,000	
Papua New Guinea								
Philippines	184,000	182,000	42,000			15,000	20,000	
Singapore	643,000	502,000				55,000	24,000	
Sri Lanka	17,000	31,000					2,000	
Thailand	98,000	194,000					8,000	
Vietnam								
** Subtotal **	13,278,000	6,342,000	909,000	955,000	9,000	490,000	445,000	5,000
*** Total ***	60,520,000	35,088,000	15,158,000	12,477,000	36,000	2,567,000	3,601,000	192,000

NOTE: Values may not add up to subtotals due to rounding. Emissions of less than 500 tons per year are not reported.

**TABLE A-5. WORLD PETROLEUM INDUSTRY PRODUCT TRANSPORTATION  
CO<sub>2</sub> EMISSIONS ESTIMATE**

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
<b>** Region: North America</b>				
Canada	110,000	507,000	219,000	44,000
Mexico	104,000	481,000	208,000	41,000
Other North American	1,000	3,000	1,000	
United States of America	1,210,000	5,582,000	2,413,000	480,000
<b>** Subtotal **</b>	<b>1,425,000</b>	<b>6,573,000</b>	<b>2,841,000</b>	<b>565,000</b>
<b>** Region: Central and South America</b>				
Argentina	36,000	168,000	72,000	14,000
Bahamas	1,000	7,000	3,000	1,000
Barbados				
Bolivia	1,000	6,000	3,000	1,000
Brazil	92,000	427,000	184,000	37,000
Chile	8,000	36,000	15,000	3,000
Colombia	15,000	69,000	30,000	6,000
Costa Rica				
Cuba	18,000	85,000	37,000	7,000
Dominican Republic	3,000	16,000	7,000	1,000
Ecuador	7,000	34,000	15,000	3,000
Guatemala	2,000	9,000	4,000	1,000
Jamaica	3,000	14,000	6,000	1,000
Netherlands Antilles and Aruba	5,000	25,000	11,000	2,000
Other Central/South American	11,000	49,000	21,000	4,000
Panama	2,000	11,000	5,000	1,000
Peru	12,000	54,000	24,000	5,000
Puerto Rico	13,000	60,000	26,000	5,000
Suriname				
Trinidad and Tobago	1,000	7,000	3,000	1,000

TABLE A-5. (Continued)

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
United States Virgin Islands	3,000	16,000	7,000	1,000
Uruguay	2,000	10,000	4,000	1,000
Venezuela	30,000	140,000	60,000	12,000
<b>** Subtotal **</b>	<b>269,00</b>	<b>1,240,000</b>	<b>536,000</b>	<b>107,000</b>
<b>** Region: Western Europe</b>				
Austria	17,000	76,000	33,000	7,000
Belgium	34,000	158,000	68,000	14,000
Denmark	18,000	84,000	36,000	7,000
Finland	17,000	78,000	34,000	7,000
France	126,000	583,000	252,000	50,000
Germany, Federal Republic of	191,000	883,000	382,000	76,000
Greece	23,000	105,000	46,000	9,000
Ireland	7,000	32,000	14,000	3,000
Italy	145,000	668,000	289,000	57,000
Luxembourg	2,000	11,000	5,000	1,000
Netherlands	41,000	190,000	82,000	16,000
Norway	14,000	63,000	27,000	5,000
Other Western Europe	3,000	12,000	5,000	1,000
Portugal	13,000	61,000	27,000	5,000
Spain	60,000	278,000	120,000	24,000
Sweden	30,000	139,000	60,000	12,000
Switzerland and Liechtenstein	23,000	105,000	45,000	9,000
United Kingdom	121,000	556,000	240,000	48,000
Yugoslavia	25,000	114,000	49,000	10,000
<b>** Subtotal **</b>	<b>909,000</b>	<b>4,195,000</b>	<b>1,813,000</b>	<b>360,000</b>



TABLE A-5. (Continued)

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
<b>** Region: Eastern Europe and U.S.S.R.</b>				
Albania	2,000	11,000	5,000	1,000
Bulgaria	24,000	111,000	48,000	10,000
Czechoslovakia	25,000	114,000	49,000	10,000
German Democratic Republic	28,000	128,000	55,000	11,000
Hungary	15,000	67,000	29,000	6,000
Poland	25,000	116,000	50,000	10,000
Romania	24,000	109,000	47,000	9,000
Union of Soviet Socialist Republics	659,000	3,042,000	1,315,000	261,000
<b>** Subtotal **</b>	<b>802,000</b>	<b>3,700,000</b>	<b>1,600,000</b>	<b>318,000</b>
<b>** Region: Middle East</b>				
Bahrain	1,000	7,000	3,000	1,000
Cyprus	2,000	10,000	4,000	1,000
Iraq	22,000	102,000	44,000	9,000
Israel	11,000	51,000	22,000	4,000
Jordan	5,000	25,000	11,000	2,000
Kuwait	9,000	40,000	17,000	3,000
Lebanon	4,000	19,000	8,000	2,000
Neutral Zone				
Oman				
Other Middle East	8,000	37,000	16,000	3,000
Qatar				
Saudi Arabia	64,000	295,000	127,000	25,000
Syria	14,000	66,000	28,000	6,000
Turkey	32,000	149,000	64,000	13,000
United Arab Emirates	11,000	52,000	22,000	4,000

TABLE A-5. (Continued)

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
Yemen				
Yemen, People's Democratic Republic of	3,000	16,000	7,000	1,000
<b>** Subtotal **</b>	<b>188,000</b>	<b>866,000</b>	<b>374,000</b>	<b>74,000</b>
<b>** Region: Africa</b>				
Algeria	11,000	50,000	21,000	4,000
Angola and Cabinda	2,000	10,000	4,000	1,000
Benin				
Cameroon				
Congo				
Egypt	36,000	166,000	72,000	14,000
Gabon				
Ghana				
Ivory Coast	3,000	14,000	6,000	1,000
Kenya	3,000	13,000	6,000	1,000
Libya	12,000	53,000	23,000	5,000
Morocco	7,000	32,000	14,000	3,000
Nigeria	18,000	83,000	36,000	7,000
Other Africa	21,000	96,000	42,000	8,000
South Africa Customs Union	27,000	124,000	54,000	11,000
Sudan	2,000	11,000	5,000	1,000
Tunisia	4,000	19,000	8,000	2,000
Zaire	2,000	8,000	3,000	1,000
<b>** Subtotal **</b>	<b>147,000</b>	<b>680,000</b>	<b>294,000</b>	<b>58,000</b>
<b>** Region: Far East and Oceania</b>				
Australia	49,000	227,000	98,000	19,000
Bangladesh				

TABLE A-5. (Continued)

Country	Marine (tons/year)	Pipeline (tons/year)	Truck (tons/year)	Rail (tons/year)
Brunel Darussalam				
Burma	1,000	6,000	2,000	
China (Mainland)	154,000	710,000	307,000	61,000
China (Taiwan)	27,000	125,000	54,000	11,000
Guam		2,000	1,000	
Hong Kong	9,000	41,000	18,000	3,000
India	74,000	343,000	148,000	29,000
Indonesia	43,000	198,000	86,000	17,000
Iran	65,000	298,000	129,000	26,000
Japan	268,000	1,234,000	533,000	106,000
Korea, North	6,000	29,000	13,000	3,000
Korea, South	43,000	199,000	86,000	17,000
Malaysia	17,000	76,000	33,000	7,000
New Zealand	7,000	32,000	14,000	3,000
Other Far East	12,000	57,000	25,000	5,000
Pakistan	16,000	74,000	32,000	6,000
Papua New Guinea				
Philippines	16,000	75,000	32,000	6,000
Singapore	25,000	113,000	49,000	10,000
Sri Lanka	3,000	14,000	6,000	1,000
Thailand	21,000	98,000	43,000	8,000
Vietnam	3,000	13,000	5,000	1,000
** Subtotal **	859,000	3,964,000	1,713,000	341,000
*** Total ***	4,599,000	21,218,000	9,170,000	1,823,000

NOTE: Values may not add up to subtotals and totals due to rounding. Emissions of less than 500 tons per year are not reported.

TABLE A-6. WORLD PETROLEUM INDUSTRY END USE CO<sub>2</sub> EMISSIONS ESTIMATES

Country	Gasoline (tons/yr)	Jet Fuel (tons/year)	Kerosene (tons/year)	Distillate Fuel Oil (tons/year)	Residual Fuel Oil (tons/year)	Liquid Petroleum Gas (tons/year)
<b>** Region: North America</b>						
Canada	82,704,000	14,324,000	7,162,000	63,985,000	24,602,000	2,447,000
Mexico	54,041,000	5,116,000	5,116,000	39,024,000	89,444,000	2,006,000
Other North American	149,000	171,000		703,000	191,000	
United States of America	1,075,748,000	236,181,000	16,200,000	523,133,000	241,061,000	20,449,000
<b>** Subtotal **</b>	<b>1,212,642,000</b>	<b>255,792,000</b>	<b>28,478,000</b>	<b>626,845,000</b>	<b>355,298,000</b>	<b>24,902,000</b>
<b>** Region: Central and South America</b>						
Argentina	16,123,000	2,728,000	1,876,000	27,071,000	18,881,000	912,000
Bahamas	448,000	171,000		703,000	1,526,000	
Barbados						
Bolivia	896,000	341,000	171,000		954,000	76,000
Brazil	47,622,000	8,185,000	1,364,000	71,896,000	38,905,000	1,863,000
Chile	3,881,000	853,000	682,000	5,625,000	3,051,000	195,000
Colombia	14,331,000	1,535,000	853,000	5,625,000	3,242,000	301,000
Costa Rica						
Cuba	3,881,000	682,000	2,387,000	8,438,000	20,025,000	371,000

TABLE A-6. (Continued)

Country	Gasoline (tons/yr)	Jet Fuel (tons/year)	Kerosene (tons/year)	Distillate Fuel Oil (tons/year)	Residual Fuel Oil (tons/year)	Liquid Petroleum Gas (tons/year)
Dominican Republic	1,194,000	512,000	512,000	1,582,000	3,051,000	64,000
Ecuador	4,180,000	682,000	682,000	4,043,000	3,624,000	192,000
Guatemala	896,000	171,000	171,000	1,582,000	572,000	21,000
Jamaica	746,000	512,000	171,000	703,000	3,624,000	45,000
Netherlands	299,000	171,000	171,000	1,582,000	8,391,000	424,000
Antilles and Aruba						
Other Central, South American	4,180,000	1,535,000	853,000	7,207,000	5,912,000	
American Panama	746,000	341,000		1,582,000	1,907,000	132,000
Peru	4,479,000	1,194,000	3,752,000	5,977,000	6,294,000	228,000
Puerto Rico	7,464,000	2,217,000	171,000	3,340,000	10,489,000	163,000
Suriname						
Trinidad and Tobago	1,344,000	341,000		527,000	381,000	397,000
United States Virgin Islands	299,000	853,000		1,230,000	4,196,000	722,000
Uruguay	746,000	171,000	171,000	1,582,000	1,526,000	44,000
Venezuela	25,080,000	2,558,000	1,364,000	11,426,000	12,968,000	1,591,000
** Subtotal **	138,835,000	25,241,000	15,351,000	161,721,000	149,519,000	7,741,000

TABLE A-6. (Continued)

Country	Gasoline (tons/yr)	Jet Fuel (tons/year)	Kerosene (tons/year)	Distillate Fuel Oil (tons/year)	Residual Fuel Oil (tons/year)	Liquid Petroleum Gas (tons/year)
<b>** Region: Western Europe</b>						
Austria	8,808,000	853,000		10,195,000	10,489,000	270,000
Belgium	9,853,000	2,217,000	341,000	31,465,000	20,025,000	863,000
Denmark	5,374,000	2,558,000	171,000	18,633,000	6,866,000	247,000
Finland	6,121,000	341,000		14,590,000	10,489,000	319,000
France	58,072,000	11,425,000	171,000	125,861,000	33,756,000	2,411,000
Germany, Federal Republic of	88,974,000	14,836,000	171,000	197,933,000	44,627,000	1,997,000
Greece	7,016,000	3,922,000		16,348,000	15,448,000	509,000
Ireland	2,836,000	853,000	341,000	4,922,000	3,814,000	74,000
Italy	42,546,000	6,310,000	1,194,000	106,349,000	116,716,000	3,715,000
Luxembourg	1,194,000	341,000		2,109,000	763,000	
Netherlands	14,331,000	5,116,000	512,000	25,137,000	31,849,000	1,829,000
Norway	6,121,000	1,194,000	1,535,000	12,305,000	3,433,000	391,000
Other Western Europe	597,000	512,000		1,406,000	2,289,000	
Portugal	3,732,000	1,876,000	171,000	7,910,000	11,443,000	415,000
Spain	23,288,000	7,503,000		45,880,000	34,900,000	1,713,000
Sweden	14,331,000	2,558,000		21,446,000	16,783,000	566,000

TABLE A-6. (Continued)

Country	Gasoline (tons/yr)	Jet Fuel (tons/year)	Kerosene (tons/year)	Distillate Fuel Oil (tons/year)	Residual Fuel Oil (tons/year)	Liquid Petroleum Gas (tons/year)
Switzerland and Liechtenstein	11,644,000	3,581,000		23,203,000	2,289,000	175,000
United Kingdom	77,330,000	21,487,000	7,333,000	64,689,000	44,436,000	2,426,000
Yugoslavia	8,509,000	1,535,000		16,875,000	19,262,000	807,000
** Subtotal **	390,677,000	89,018,000	11,940,000	747,256,000	429,677,000	18,727,000
** Region: Eastern Europe and U.S.S.R.						
Albania	746,000		171,000	1,230,000	2,479,000	53,000
Bulgaria	6,121,000		853,000	14,414,000	24,793,000	397,000
Czechoslovakia	7,016,000		1,535,000	13,008,000	25,746,000	603,000
German Democratic Republic	14,033,000			20,743,000	16,211,000	1,053,000
Hungary	5,524,000		853,000	12,481,000	8,201,000	292,000
Poland	12,241,000		1,194,000	22,325,000	9,917,000	511,000
Romania	5,971,000		1,705,000	14,766,000	22,695,000	817,000
Union of Soviet Socialist Republics	250,202,000	70,769,000	47,407,000	283,012,000	584,534,000	16,297,000
** Subtotal **	301,854,000	70,769,000	53,718,000	381,979,000	694,576,000	20,023,000

TABLE A-6. (Continued)

Country	Gasoline (tons/yr)	Jet Fuel (tons/year)	Kerosene (tons/year)	Distillate Fuel Oil (tons/year)	Residual Fuel Oil (tons/year)	Liquid Petroleum Gas (tons/year)
<b>** Region: Middle East</b>						
Bahrain	597,000	171,000	1,194,000	527,000	191,000	322,000
Cyprus	448,000	682,000		879,000	1,907,000	24,000
Iraq	7,912,000	1,194,000	4,775,000	14,414,000	12,587,000	422,000
Israel	3,881,000	1,705,000	853,000	3,516,000	11,061,000	238,000
Jordan	1,194,000	682,000	682,000	2,637,000	4,959,000	132,000
Kuwait	4,180,000	1,705,000	171,000	2,637,000	7,247,000	1,085,000
Lebanon	2,389,000			1,406,000	3,624,000	49,000
Neutral Zone						
Oman						
Other Middle East	3,284,000	1,023,000	512,000	6,328,000	3,624,000	
Qatar						
Saudi Arabia	23,139,000	6,992,000	512,000	45,352,000	42,910,000	1,334,000
Syria	2,986,000	1,194,000	682,000	11,250,000	10,871,000	323,000
Turkey	8,360,000	1,194,000	1,364,000	25,489,000	24,411,000	930,000
United Arab Emirates	3,135,000	2,899,000	171,000	7,383,000	7,438,000	238,000
Yemen						



TABLE A-6. (Continued)

Country	Gasoline (tons/yr)	Jet Fuel (tons/year)	Kerosene (tons/year)	Distillate Fuel Oil (tons/year)	Residual Fuel Oil (tons/year)	Liquid Petroleum Gas (tons/year)
Yemen, People's Democratic Republic of	1,045,000	341,000	512,000	1,230,000	3,242,000	214,000
** Subtotal **	62,550,000	19,782,000	11,428,000	123,048,000	134,072,000	5,311,000
<b>** Region: Africa</b>						
Algeria	6,270,000	1,535,000	171,000	9,844,000	1,335,000	616,000
Angola and Cabinda	299,000	512,000	171,000	1,055,000	1,907,000	43,000
Benin						
Cameroon						
Congo						
Egypt	7,315,000	2,899,000	8,697,000	15,293,000	34,519,000	648,000
Gabon						
Ghana						
Ivory Coast	1,045,000	341,000	1,194,000	1,582,000	1,526,000	91,000
Kenya	896,000	512,000	512,000	1,758,000	1,716,000	119,000
Libya	3,881,000	2,046,000	512,000	7,207,000	7,819,000	436,000
Morocco	1,493,000	853,000	171,000	5,274,000	5,340,000	205,000
Mozambique						
Nigeria	12,689,000	1,535,000	5,798,000	7,031,000	4,577,000	574,000

TABLE A-6. (Continued)

Country	Gasoline (tons/yr)	Jet Fuel (tons/year)	Kerosene (tons/year)	Distillate Fuel Oil (tons/year)	Residual Fuel Oil (tons/year)	Liquid Petroleum Gas (tons/year)
Other Africa	9,106,000	4,093,000	2,728,000	15,293,000	6,675,000	
South Africa	14,929,000	1,705,000	1,364,000	18,457,000	12,396,000	574,000
Customs Union						
Sudan	746,000	341,000		2,285,000	1,144,000	33,000
Tunisia	746,000	512,000	512,000	3,516,000	2,670,000	45,000
Zaire	448,000	682,000		1,758,000	191,000	23,000
** Subtotal **	59,863,000	17,566,000	21,830,000	90,353,000	81,815,000	3,407,000
<b>** Region: Far East and Oceania</b>						
Australia	41,501,000	7,674,000	682,000	27,598,000	7,819,000	894,000
Bangladesh						
Brunel Darussalam						
Burma	746,000			1,055,000	381,000	42,000
China (Mainland)	55,534,000	9,379,000	4,263,000	86,662,000	133,117,000	2,915,000
China (Taiwan)	9,106,000	2,046,000	341,000	1,899,000	28,988,000	755,000
Guam	299,000	171,000		352,000		
Hong Kong	746,000	3,581,000	512,000	5,274,000	6,675,000	
India	9,704,000	6,139,000	26,091,000	67,677,000	29,560,000	1,429,000
Indonesia	12,540,000	2,046,000	20,293,000	30,059,000	13,922,000	946,000

TABLE A-6. (Continued)

Country	Gasoline (tons/yr)	Jet Fuel (tons/year)	Kerosene (tons/year)	Distillate Fuel Oil (tons/year)	Residual Fuel Oil (tons/year)	Liquid Petroleum Gas (tons/year)
Iran	16,123,000	1,705,000	21,828,000	45,704,000	35,091,000	702,000
Japan	97,931,000	9,209,000	74,521,000	155,041,000	158,101,000	5,563,000
Korea, North	3,583,000		853,000	4,395,000	2,670,000	56,000
Korea, South	4,180,000	4,945,000	3,752,000	31,114,000	38,905,000	1,149,000
Malaysia	7,464,000	1,705,000	1,023,000	10,547,000	9,726,000	277,000
New Zealand						
Other Far East	3,284,000	3,581,000	2,387,000	8,613,000	5,149,000	
Pakistan	3,284,000	1,876,000	3,240,000	13,887,000	7,819,000	160,000
Papua New Guinea						
Philippines	4,180,000	1,535,000	1,194,000	8,613,000	15,257,000	376,000
Singapore	1,493,000	4,263,000		7,031,000	35,663,000	1,100,000
Sri Lanka	448,000	341,000	512,000	2,461,000	2,098,000	66,000
Thailand	6,718,000	4,434,000	341,000	19,512,000	8,391,000	285,000
Vietnam	1,045,000		512,000	1,758,000	1,716,000	
** Subtotal **	279,909,000	64,630,000	162,345,000	529,252,000	541,048,000	16,715,000
*** Total ***	2,446,330,000	542,798,000	305,090,000	2,660,454,000	2,386,005,000	96,826,000







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